AD 763 324

RECEIVER (INFRARED SEEKERS)

Army Test and Evaluation Command
Aberdeen Proving Ground, Maryland

June 1973

AD-763324

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST OPERATIONS PROCEDURES

AMSTE-RP-702-104
*Test Operations Procedure 5-2-527 — 5 June 1973
AD763324

RECEIVER (INFRARED SEEKERS)

*This TOP supersedes MTP 5-2-527, dtd 12 October 1967.

Approved for Public release, distribution unlimited.

UNCLASSIFIED
Security Classification

AD763324

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
US Army Test and Evaluation Command Test Operation Procedure "Rec iver (Infrared Seeker

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Fina.

5. AUTHOR(S) (First name, middle initial, last name)

6. REPORT DATE 5 June 1973	7a. TOTAL NO. OF PAGES 54	7b. NO. OF REFS 3
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. AMCR 310-6 d.	9a. ORIGINATOR'S REPORT NUMBER(S) TOP 5-2-527 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Headquarters US Army Test and Evaluation Command Aberdeen Proving Ground, Maryland 21005

13. ABSTRACT

Describes a method for evaluation of heat seeking missiles. Discusses preliminary activities, equipment, and facilities required. Provides procedures for gyro spin-up time, gyro spin-up current, gyro spin-down time, maximum look angle, recovery time, maximum slew rate, gyro drift, signal-to-noise ratio, cool-down time, field-of-view, caging accuracy, static gain, spectral responsivity, intercept ability, gyro spin versus slew rate, maximum tracking versus gyro spin, maximum tracking rate versus target intensity, low temperature storage and operation, high temperature storage and operation, transportation vibration, handling shock, and boost shock. Discusses gyro spin-up time, maximum look angle, signal-to-noise ratio and low temperature storage. Limited to infrared seekers.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

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UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Gyroscope						
Infrared Seekers						
Tracking and Hitting Performance						

SECTION I
GENERAL

1. Purpose and Scope.

a. This procedure applies to all passive heat seeking missiles with seekers having the following operational and physical characteristics:

(1) The seeker element which acquires, locks on, and tracks a heat source is a spinning optical system constructed such that it is a gyroscope with three degrees of freedom. In this TOP, the element is called "gyro."

(2) The axis of the gyro is free to move (within limits) in relation to the longitudinal axis of the missile. In this TOP, the angle between the two axes is called "look angle."

(3) Caging of the gyro is done by purely electronic means. When the gyro is caged, the look angle is zero.

b. Features and characteristics of the test item to be evaluated by the use of this TOP are:

(1) Spin, precession, and drift characteristics of the gyro, along with electrical and mechanical limitations.

(2) Operational parameters of the infrared detector and associated seeker electronics, including static gain, spectral responsivity, field-of-view, signal-to-noise ratio as a function of infrared irradiation, minimum infrared input for given performance criteria, and a method to predict the ability of the seeker to acquire and home on a given target under a variety of environmental conditions.

(3) Susceptibility of the seeker to degradation during simulated environmental conditions of storage and operation.

c. Objectives of the tests described in this TOP are to determine the degree of compliance of the seeker to the stated and implied operational and physical parameters specified in requirements documents,

applicable military standards, TECOM regulations, and standards of performance established by the test agency responsible for the evaluation of the seeker. The test objectives in each instance are not limited to the determination of whether the test item meets requirements; but, rather, the objectives are intended to determine the extent by which the test item exceeds the requirements (or fails to meet requirements).

d. The procedures in this TOP are designed for evaluation of the operational characteristics of infrared seeker only. Test objectives and methods have not been included to evaluate:

(1) Weight, dimensions, center of gravity, and power requirements of the seeker.

(2) Maneuverability, intercept probability, and other inflight parameters of the missile of which the seeker is a part.

(3) Guidance ability of the airframe resulting from information supplied by the seeker.

2. Background.

a. Infrared receivers, as used in conjunction with guided missiles, enable the missile to track and "home in" on infrared energy emitted from a target. The infrared receiver (hereafter referred to as the seeker) contains an infrared detector and reticle mounted in a three axis gyroscope with ground faces such that the gyroscope forms the optical system for the seeker. The reticle chops the incoming infrared energy in such a manner that the output of the detector has a pattern which can be used in the electrical system of the seeker to cause the gyroscope to precess always toward the moving target. Guidance signals are developed by the seeker and used by the airframe of the missile to steer the missile towards the target.

b. Because of the exacting requirements for extremely accurate missile trajectories and the high cost of firing each missile, it is necessary that the acquisition and tracking capabilities of the seeker be fully evaluated in the laboratory prior to field testing against actual airborne infrared targets.

c. This TOP is designed to measure the limitations as well as the capabilities of a seeker in acquisition of a target, tracking the target, and degradation due to aging of components and operation in extremes of environmental exposure. Ability to acquire a target is measured in terms of total amount of energy reaching the seeker and also as a function of the spectral distribution of that energy (experience has shown spectral distribution to be equal in importance to the amount of energy); tracking capability is measured in terms of the length of time the seeker can be

expected to track a given angular velocity as well as the effect of angular acceleration of the target; the absolute maximum tracking ability of the seeker can also be determined by tests described in this TOP.

3. Equipment and Facilities.

a. Elapsed time meter with voltage control of start and stop functions.

b. Cage coil rectifier to give filtered d.c. output equal to a.c. (rms) input from the seeker cage coil.

c. Frequency meter with digital read-out to measure cage coil output frequency.

d. Vacuum tube voltmeter (VTVM) with voltage ranges to accommodate the voltage outputs of the particular seeker under test.

e. Strip chart recorder with the following salient features minimum:

(1) Frequency range of zero to 500 cycles per second.

(2) Writing speed of 25,000 inches per second spot velocity.

(3) Linearity of plus or minus 2.0 percent of reading with deflection of three inches.

(4) Record speed of 20 inches per second.

(5) Timing marks from a built-in time base generator at tenth-second (plus or minus 4.0 percent) intervals.

f. X-Y recorder (two each) with the following salient features minimum:

(1) Input voltage range from 0.1 millivolt per inch to 50 volts per inch, switch selectable in steps with continuously variable control between calibrated positions for each axis.

(2) Accuracy of plus or minus 0.15 percent of full scale each axis.

(3) Frequency response d.c. to 4.0 cycles per second within plus or minus 3.0 db.

(4) Transient response of 100 milliseconds when set for eight-inch deflection each axis.

(5) Internal time base generator for X-axis with accuracy of plus or minus two percent of full scale; linearity plus or minus one percent of full scale; switch selectable sweep rates from 0.01 inch per second to two inches per second.

(6) Remote connector inputs for time base start, reset, and pen lift.

g. Integrating digital voltmeter with the following salient features minimum:

(1) Five voltage ranges from 0.1 to 1,000 volts full scale.

(2) Input impedance not less than 10 megohms for input of 10 volts to 1,000 volts.

(3) Common mode rejection of 120 db at 60 cycles.

(4) Accuracy of plus or minus 0.01 percent of reading plus or minus one digit.

(5) Integration range from zero to 1,000 volt-seconds.

(6) Remote control by relay closure to ground of the start and stop function.

h. Rate Table with the following salient features minimum (see fig. 1):

(1) Push button selectable rates of turn, acceleration, and direction of rotation; when stopping, the rate table will slow down at the rate selected for acceleration.

(2) A seeker holding fixture to accomodate the seeker under test:

(a) The seeker will be mounted so that the precession axis of the seeker gyro is centered over the rotation axis of the rate table.
(b) The holding fixture shall allow the seeker to be rotated about its longitudinal axis 360 degrees in each direction.
(c) The holding fixture shall be equipped with a motordrive to roll the seeker at its nominal in-flight roll rate, one-half the roll rate, and twice the roll rate during operation of the rate table.*

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*The motor driven roll feature may be deleted for rate tables designed to test a seeker used with a missile which does not roll during flight.

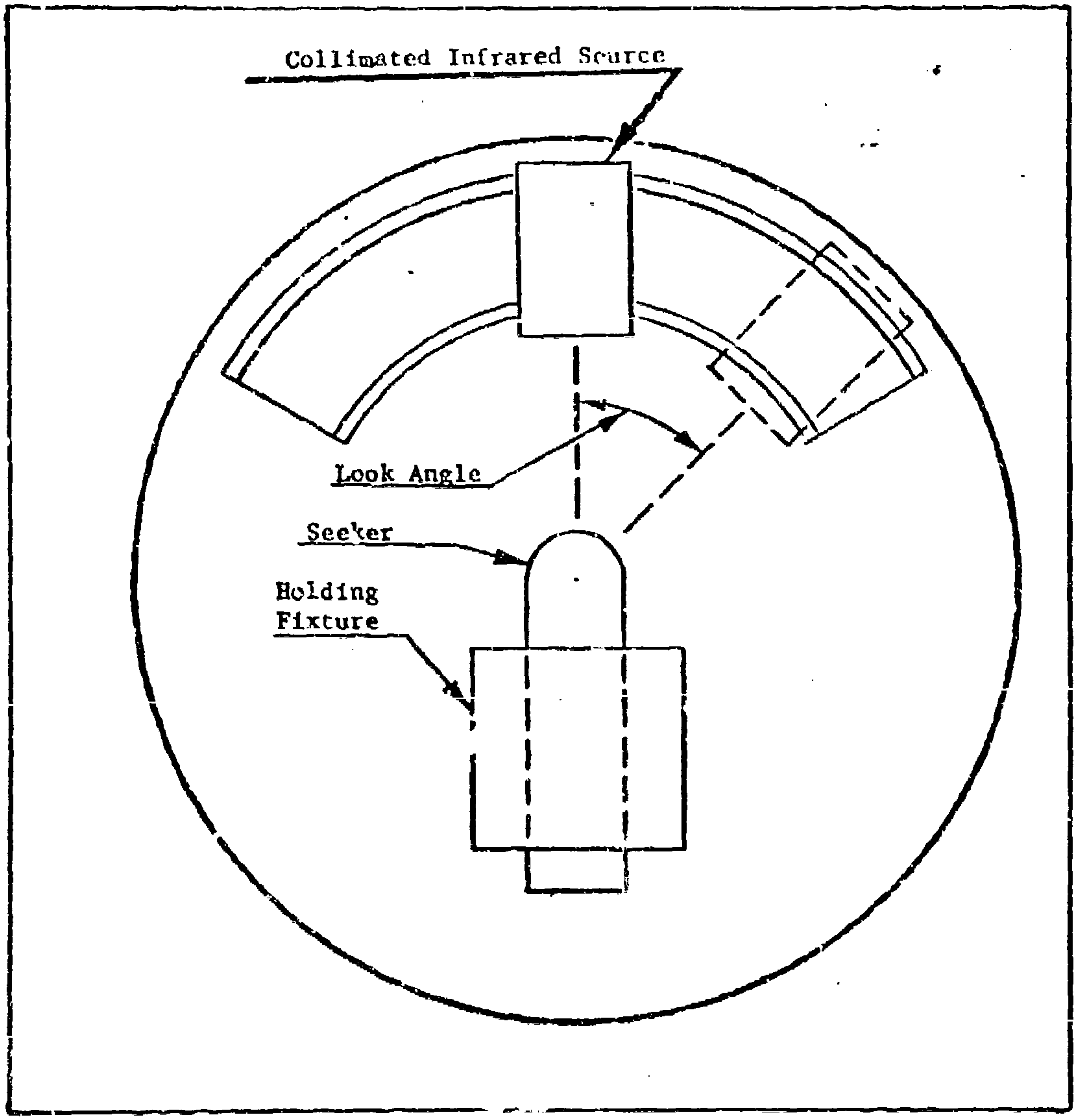

Figure 1. Layout of Components on Top cf Rate Table, Not to Scale.

(3) A collimated infrared source to illuminate the seeker under test, consisting of a blackbody, temperature controller for the blackbody, interchangeable apertures to determine the effective radiating area of the blackbody, and various interchangeable neutral density infrared attenuators for the blackbody, as required. Collimation of the blackbody output energy shall be by reflective optics.

(4) A look angle drive unit shall be provided to support the infrared source and position it such as to provide a look angle for the seeker as required by the requirements document. The look angle drive shall be motor driven so that it will automatically position the infrared source at a pushbutton selectable position of look angle. The rate of drive shall be two degrees per second clockwise and counterclockwise. The look angle drive unit shall output a d.c. voltage proportional to look angle for use with the X-Y recorder.

i. An infrared signal generator to illuminate the seeker under test with monochromatic infrared energy of constant known amplitude and constant narrow bandwidth tunable over the spectral region of seeker sensitivity as specified in the requirements document. The signal generator shall output a d.c. voltage proportional to the wavelength of the monochromatic output energy and shall have an input from the seeker detector voltage which shall adjust the level of the output energy so as to maintain the output of the detector at a constant value (see figure 12, appendix B).

j. Environmental shrouds to be placed over the seeker on the rate table to provide for simulated high and low temperature operation of the seeker. Environmental chambers for simulated high and low temperature storage of the seeker.

k. Shock and vibration equipment as required, for simulation of transportation and handling environments.

l. Instrumentation type magnetic tape recorder/reproducer with three Frequency Modulation (FM) record and playback channels.

m. Power supply to furnish one volt as required in paragraph 17, Spectral Responsivity.

n. Relay and relay amplifier to control the one-volt power supply.

4. Preliminary Activities

a. Divide the 15 test items into five groups of three seekers each. Designate the groups with letters A through E and number the seekers A_1, A_2, A_3, B_1, B_2, etc. through the fifteenth seeker which will have the designation of E_3. See figure 13, appendix B for flow diagram of seekers through the test program.

b. Prepare a master log book with permanently bound pages for each seeker and label each log with the designation of the appropriate seeker. Each log book shall contain the clock time for each time power is applied to the seeker and the time power is removed; there shall be a daily up-date of accumulated operating time for each of the seekers.

c. Establish a priority for substituting operational seekers for any that may be defective or may suffer a catastrophic failure during the test program such that seeker A_3 shall be the first to have its designation changed to that of the failed item; B_3 shall be the second; and C_3 shall be the third. If more than three items fail during the test program, this shall be sufficient grounds to take the position that the test item is not suitable for testing.

d. Assure that all test equipment required for the test program is on hand and is operational prior to start of the first subtest.

e. Establish a folder or other container for raw data collection and label it Test Data Package.

f. Observe all warnings, danger signals, and safety precautions and install seeker A_1 in the seeker holding fixture on the rate table according to instructions in applicable documents.

SECTION II
TEST PROCEDURES

5. Gyro Spin-Up Time

a. Objective. Determine the time required at laboratory ambient conditions for the gyro to reach its nominal (regulated) operating speed in revolutions per second with the gyro caged. Spin-up time is indicative of the condition of the gyro spin bearings.

b. Standards. Spin-up time of the gyro shall not exceed four seconds unless a shorter time is specified in the requirements document.

c. Method. (See paragraph 29)

(1) Connect the digital frequency meter to measure the frequency of the a.c. voltage output from the cage coil and connect the strip chart recorder to record the output from the cage coil or other source of a.c. voltage with frequency equal to gyro spin in revolutions per second. Refer to figure 2 for instrumentation and connections.

(2) Adjust the recorder for a deflection of at least three inches; 10 timing marks per second; and chart speed of 20 inches per second. Start the recorder.

(3) After the recorder is running at selected speed, turn on power to the seeker to spin up the gyro; do not uncage the gyro.

(4) When the gyro speed stabilizes (as indicated by the frequency meter) at its nominal operating speed, turn off the recorder; turn off power to the seeker.

(5) Locate, on the recording just completed, the last full one-second period; mark the beginning and end of the period; count the cycles of voltage which occured during that period to determine that the gyro was operating at its specified regulated speed (if not, adjust the gyro speed and repeat steps (2) through (5)).

(6) Working toward the beginning of the recording, locate by counting cycles of voltage, the first full one-second period recorded which contains the required number of cycles to indicate that the gyro was running at the proper speed; mark the beginning and end of this period on the recording. The beginning should be located with accuracy of one-tenth second.

(7) From the beginning of the time period just located, count the tenth-second timing marks backward toward the start of the recording. Divide the number of marks by 10 to give the gyro spin-up time.

d. Data Required. The data required is the time in seconds, accurate to 0.1 second, required for the gyro to spin up from zero to the nominal operating speed in revolutions per second. The test will be performed one time on each seeker in each group (15 seekers total). The spin-up time for each seeker, with seeker identification and other pertinent information, will be entered in the master log book. The strip charts will be inserted in the test data package.

e. Analytical Plan. Compare the measured spin-up times to the requirements for spin-up time in the requirements document. Divide the smaller number by the larger number and multiply the quotient obtained by 100 to give the percentage by which the test items met the requirements. Enter this percentage in the master log for each seeker tested. The

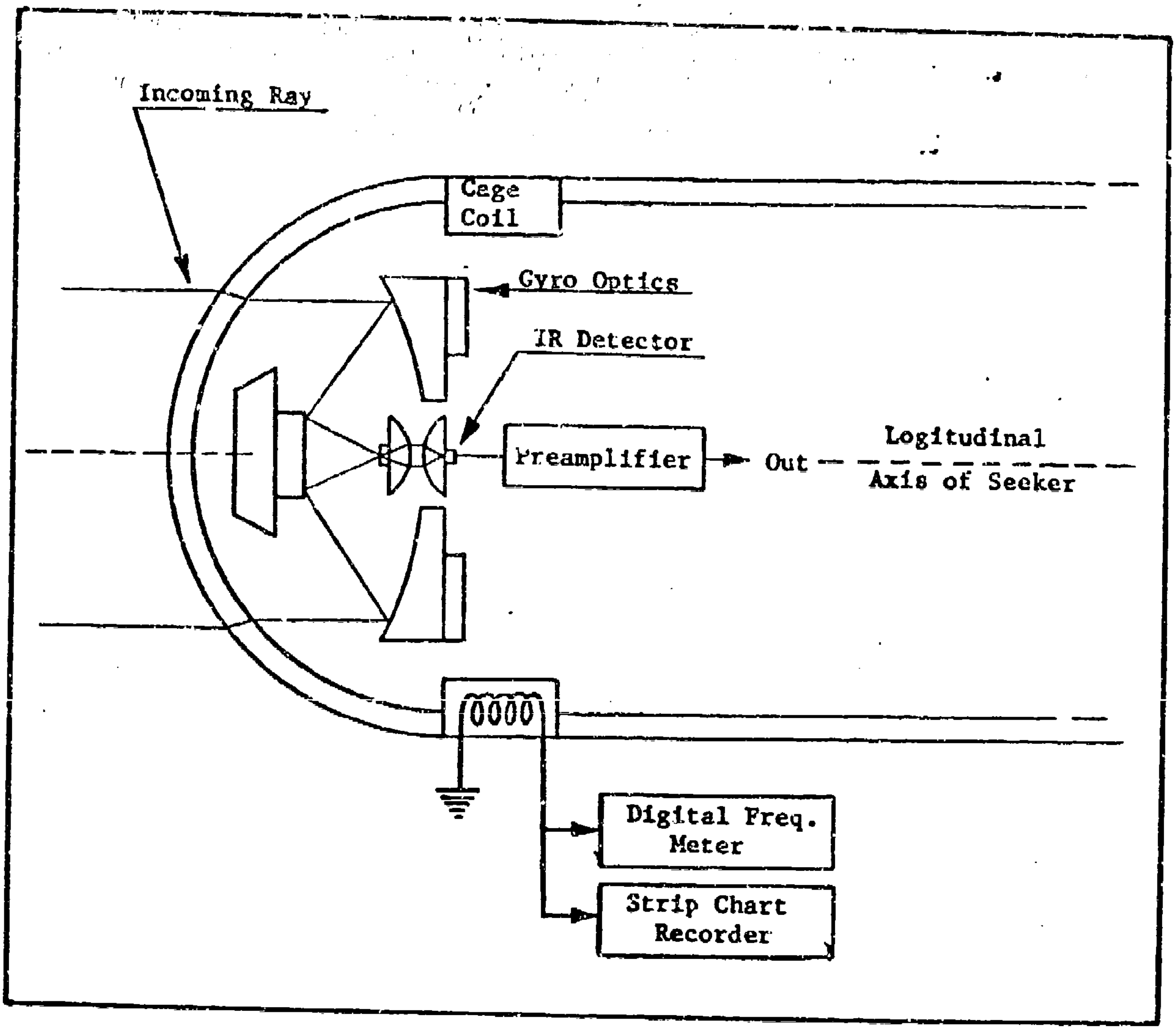

Figure 2. Instrumentation for Spin-Up and Spin-Down Subtests.

results of this subtest will form base line data to which the operation of the seekers will be compared later for determination of degradation which may result from further testing.

6. Gyro Spin-Up Current

a. Objective. Determine the current-time envelope during gyro spin-up under laboratory ambient conditions. The current-time envelope is indicative of the condition of the gyro spin bearings and their lubrication, especially when the envelope made at ambient temperature is compared to that made at temperature extremes.

b. Standards. None applicable.

c. Method. (see paragraph 29)

(1) Install a small resistor in the wire from the power supply to the gyro spin circuitry to develop a voltage proportional to the load required by the gyro drive coils; connect the X-Y recorder and calibrate it so that the Y-axis indicates the voltage developed across the resistor. Refer to figure 3 for instrumentation and connections.

(2) Connect the integrating digital voltmeter to measure the input to the Y-axis of the X-Y recorder.

(3) Adjust the X-axis to be driven at two inches per second by the internal time base generator.

(4) Lower the pen to writing position on the X-Y recorder.

(5) Simultaneously: start the X-Y recorder sweep; turn on gyro spin up voltage; and enable the voltmeter in continuous integrate mode. The X-Y recorder will draw the envelope of power consumed in ampere-seconds and the integrating digital voltmeter will accumulate the numerical value of the area under the curve as it is plotted on the X-Y recorder.

(6) When the gyro speed stabilizes, turn off power to the spin circuitry; lift the pen of the X-Y recorder; and disable the integrating function of the digital voltmeter.

(7) Remove the graph paper from the X-Y recorder and write the reading of the integrating digital voltmeter on the graph paper; add the graph paper to the test data package.

d. Data Required. The data required are the numerical value in ampere-seconds of the current-time envelope during spin-up of the gyro

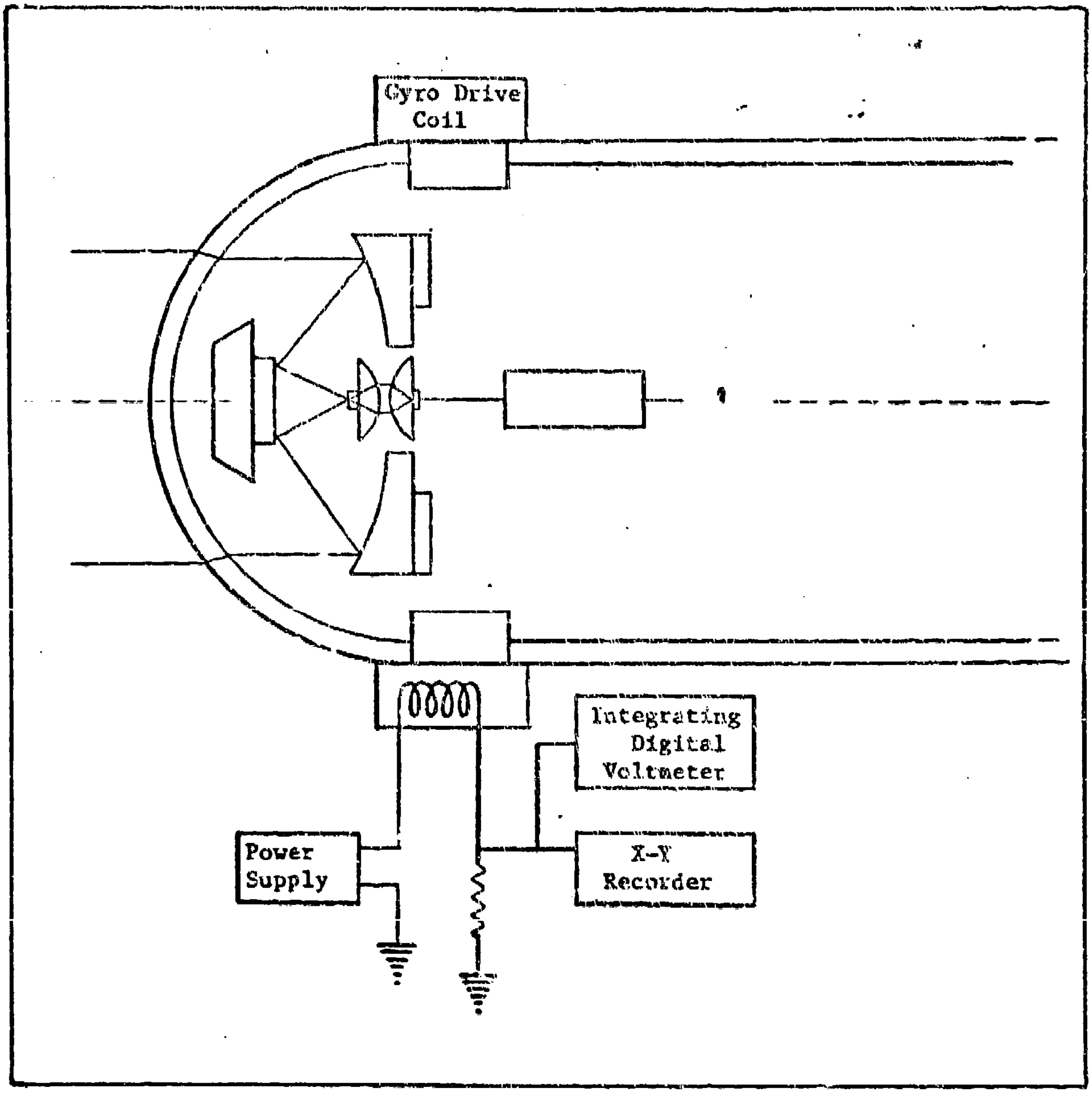

Figure 3. Instrumentation for Spin-Up Current Subtest.

and the graph of the envelope as produced by the X-Y recorder. This subtest will be performed one time on each of the seekers in all three groups (15 seekers total). Accuracy of measurement will be plus or minus one percent.

e. Analytical Plan. The results of this subtest will be used to form base line data to which the operation of the seekers will be compared later for determination of degradation which may result from further testing. The ampere-seconds required for spin-up of the gyro will be compared to the ampere-hour rating of the missile battery for determination of the percentage of the available power used for gyro spin-up.

7. Gyro Spin-Down Time.

a. Objective. Determine the time required under laboratory ambient conditions for the gyro to spin down from its regulated speed to the minimum speed which allows for satisfactory operation as specified in the requirements document.*

b. Standards. None applicable except that spin-down time shall be not less than the specified maximum time of flight of the missile.

c. Method. (see paragraph 29)

(1) Connect the digital frequency meter to measure the frequency of the a.c. voltage output from the cage coil and connect the strip chart recorder to record the output from the cage coil or other source of a.c. voltage with frequency equal to gyro spin in revolutions per second. Refer to figure 2 for instrumentation and connections.

(2) Adjust the recorder for a deflection of at least three inches; 10 timing marks per second; and chart speed of 20 inches per second.

(3) Apply power to the seeker and gyro spin-up circuitry.

(4) Apply power to the seeker holding fixture to roll the seeker at the nominal roll rate of the missile as specified in the requirements document. Omit this step when testing seekers which are used with missiles that do not roll during flight.

(5) When the gyro has stabilized at its regulated operating speed, turn on the strip chart recorder. When the recorder reaches the selected operating speed, uncage the gyro.

*This subtest is omitted for seekers which have the gyro spin powered during flight of the missile.

(6) Turn off power to the gyro spin circuitry and allow the gyro to coast down to a speed below which it will not operate within specifications.

(7) Turn off the strip chart recorder and the remainder of the seeker power.

(8) By counting cycles contained in one second periods in the recording, locate the beginning and end of the first one-second period which contains the number of cycles corresponding to the lowest operating gyro speed as specified in the requirements document.

(9) From the beginning of the one-second period just located, count the tenth-second timing marks to the point on the recording where the gyro spin power was turned off. Divide the number of marks by ten to give the gyro spin-down time.

d. Data Required. The data required is the time in seconds, accurate to 0.1 second, required for the gyro to coast down from nominal operating speed to the lowest speed at which the gyro will operate within specifications. This test will be performed one time on each seeker in each group (15 seekers total). The spin-down time for each seeker will be entered in the master log book. The strip charts will be added to the test data package.

e. Analytical Plan. Compare the measured spin-down times to the specified spin-down time in the requirements document. Divide the smaller number by the larger number and multiply the quotient obtained by 100 to give the percentage by which the test items met the requirement. Enter this percentage in the master log for each seeker tested. The results of this subtest will form base line data to which the performance of the seekers will be compared later for determination of degradation which may result from additional testing.

8. Maximum Look Angle.

a. Objective. Determine the maximum angle which the gyro can make with the longitudinal axis of the seeker. Prepare a calibration curve of seeker cage coil output versus look angle.

b. Standards. None applicable.

c. Method. (See paragraph 30)

(1) Connect the cage coil rectifier input to the output of the seeker cage coil.

(2) Connect the X-Y recorder so that the cage coil rectifier output drives the Y-axis and the look angle position of the infrared source is indicated on the X-axis, to right of center for clockwise look angle and left of center for counterclockwise look angle. Refer to figure 4 for instrumentation and connections.

(3) Apply power to the seeker and allow the gyro to spin up to its regulated speed.

(4) Enable detector cooling equipment.

(5) When the seeker acquires the target, uncage the gyro, lower the pen of the X-Y recorder and energize the look angle drive to increase the look angle clockwise. The X-Y recorder will draw the calibration curve of cage coil output versus look angle from zero degrees to maximum clockwise.

(6) When the infrared source reaches maximum look angle position lift the recorder pen, cage the gyro, and reset the look angle to zero.

(7) Repeat steps (5) and (6) driving the infrared source to maximum counterclockwise look angle position. The recorder will draw the left portion of the curve which should be a mirror image of the right portion drawn in step (5).

(8) Turn off power to the seeker.

(9) Note the reading in degrees at the end point of each curve and enter in the master log book as maximum look angle. Leave the graph paper on the recorder for use in the next subtest (para 9).

*(10) Place a new sheet of graph paper on the X-Y recorder, rotate the seeker 30 degrees about its longitudinal axis and repeat steps (3) through (9).

(11) Repeat step (10) until the seeker has been rolled through 150 degrees.

d. Data Required. The data required are the maximum angular travel of the gyro optical system in reference to the longitudinal axis of the seeker expressed in degrees, and a calibration curve of seeker cage coil output voltage versus look angle. This test will be performed one time on each of three seekers (A_1, B_1, and C_1); accuracy of measurement shall be plus or minus 0.25 degrees for look angle and plus or minus one percent for voltage output.

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*Steps (10) and (11), or portion thereof, may be omitted at the discretion of the test conductor.

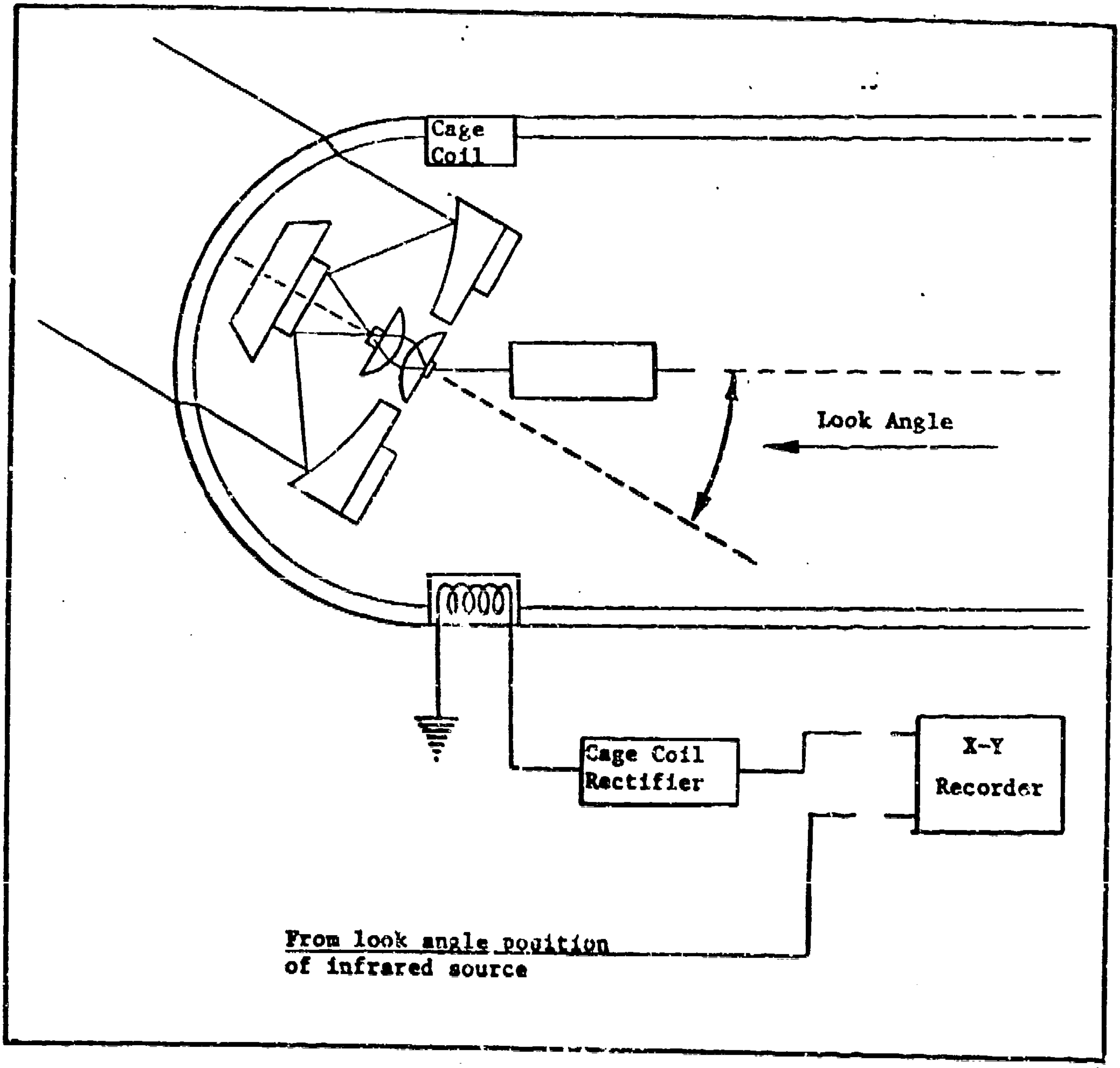

Figure 4. Maximum Look Angle Recovery Time.

e. Analytical Plan. Compare the readings obtained for maximum look angle to the specification for maximum look angle in the requirements document and determine the percentage by which the test item met the requirement; find the average of the readings obtained from the subtest and compare this number to that in the requirements document. The graph of cage coil output will be used in subsequent subtests for readout of look angle.

9. Recovery Time.

a. Objective. Determine the time required at laboratory ambient conditions for the precession circuitry to cage the gyro from maximum look angle position.

b. Standards. None applicable.

c. Method. (See paragraph 30)

(1) Connect the cage coil rectifier input to the output of the seeker cage coil.

(2) Connect the X-Y recorder so that the cage coil rectifier output drives the Y-axis and the look-angle position of the infrared source is indicated on the X-axis, to right of center for clockwise look angle and left of center for counterclockwise look angle. Refer to figure 4 for instrumentation and connections. A graph made in the previous subtest should be on the X-Y recorder, which is used as a readout device during the subtest.

(3) Apply power to the seeker and allow the gyro to spin up to its regulated speed; enable detector cooling.

(4) When the seeker acquires the target, uncage the gyro and energize the look-angle drive to position the infrared source to maximum clockwise look angle as indicated by the X-Y recorder. Do not exceed the maximum look angle determined in paragraph 8 subtest.

(5) When the infrared source has reached the maximum look angle, turn off the look-angle drive; simultaneously start the timer and cage the gyro.

(6) Stop the timer when the look angle becomes zero as indicated by the Y-axis of the X-Y recorder.

(7) Read the elapsed time on the timer and record this number in the master log book as recovery time.

(8) Annotate the graph paper with maximum look angle, recovery time in seconds, seeker identification, and any other pertinent information and add it to the test data package.

d. Data Required. The data summary required is the time in seconds required for the caging function to occur starting with the gyro at maximum look angle and ending with the gyro axis aligned with the longitudinal axis of the seeker. The accuracy for measurement shall be plus or minus 0.25 second. This subtest will be performed one time on each of the seekers used in paragraph 8 (A_1, B_1, and C_1).

e. Analytical Plan. Compare the readings obtained for recovery time to the specifications in the requirements document and determine the percentage by which the test item meets the requirement. Recovery time, in conjunction with maximum slew rate (paragraph 10), is a limiting factor in the minimum elapsed time between the decision to fire and the time of actual firing of a missile with an infrared seeker.

10. Maximum Slew Rate.

a. Objective. Determine the maximum slew rate to which the seeker can be subjected without tumbling the gyro.

b. Standards. The seeker will be capable of precessing the gyro sufficiently fast that the time to slew the seeker through 180 degrees plus the recovery time determined from the previous subtest (paragraph 9), when added together, shall not exceed a total of three seconds elapsed time; the gyro shall not lag the axis of the seeker by more than 20 degrees during slewing test. This shall be the standards for absolute maximum slew rate except when the requirements documents specify more stringent requirements on the seeker.

c. Method.

(1) Connect the X-Y recorder so that angular velocity of the rate table drives the X-axis of the recorder and the output of the cage coil is indicated on the Y-axis of the recorder.

(2) Apply power to the seeker; do not uncage the gyro.

(3) Select an acceleration rate of 10 degrees per second per second for the rate table; lower the pen on the X-Y recorder; and start the rate table clockwise.

(4) Refer to the calibration curve of look angle versus cage coil output obtained in paragraph 8 to determine when the gyro lags the longitudinal axis of the seeker by 20 degrees (look angle is 20 degrees). When the look angle is equal to 20 degrees as indicated by the Y-axis of the X-Y recorder, select zero acceleration for the rate table in order to maintain that velocity which caused the look angle to be 20 degrees. The recorder pen should stop moving in both directions. If the look angle changes, make minor changes to the rate of the table to cause the look angle to remain at 20 degrees. Note the rate of the table and enter this in the master log book as maximum slew rate clockwise.

(5) Lift the pen of the X-Y recorder; stop the rate table; turn off power to the seeker; and remove the graph paper and add it to the test data package.

(6) Install new graph paper on the X-Y recorder and repeat steps (2) through (5) with the rate table operating counterclockwise.

(7) Install new graph paper on the X-Y recorder; rotate the seeker 10 degrees about the longitudinal axis and repeat steps (2) through (6) for each roll position of the seeker until the seeker has been rotated through 180 degrees (increments of roll can be made larger at the discretion of the test officer but not to exceed 45 degrees).

d. Data Required. The data required is the maximum slew rate of the seeker which will cause the look angle of the gyro to approach, but not exceed, the maximum specified look angle. This subtest will be performed one time on each of three seekers (A_2, B_2, and C_2). The accuracy of measuring the rate of the table will be plus or minus one degree per second and the accuracy of measuring the cage coil output will be plus or minus three percent. The table rate corresponding to 20-degree look angle will be entered in the master log book for each roll position of each seeker tested. Each graph resulting from this subtest will be annotated with seeker identification and other pertinent information and will be added to the test data package.

e. Analytical Plan. Compare the maximum slew rate as determined above to the specifications in the requirements document and calculate the percentage by which the seeker meets the requirement. Calculate the time required to slew the seeker through 180 degrees at maximum slew rate and determine whether this time added to the recovery time measured in paragraph 9 is more or less than the time specified in paragraph b. above.

11. Gyro Drift.

a. Objective. Determine the rate of gyro drift by recording the change, with time, of the angle which the gyro makes with the longitudinal axis of the seeker when the gyro is operating uncaged and without an infrared input to the optics of the seeker.

b. Standards. None applicable.

c. Method.

(1) Connect the X-Y recorder so that the cage coil output drives the Y-axis and the internal time base generator drives the X-axis.

(2) Apply power to the seeker and allow the gyro to spin up to its regulated speed; enable detector cooling.

(3) When the seeker acquires the target, uncage the gyro and set the look angle at ten degrees.

(4) Adjust the sensitivity of the X-Y recorder to give three inches of deflection of the Y-axis for one degree of change of look angle.

(5) Apply power to the seeker holding fixture to roll the seeker at the nominal roll rate of the missile as specified in the requirements document. Omit this step when testing seekers which are used with missiles that do not roll during flight.

(6) Simultaneously: cover the seeker optics to exclude infrared energy; lower the pen on the X-Y recorder; start the X-axis time drive; and (if the missile flies without power to spin the gyro) turn off gyro spin voltage. The X-Y recorder will draw a graph of look angle change (gyro drift) versus time.

(7) When the graph is finished lift the pen of the recorder, turn off the power to the seeker, and remove the graph paper from the recorder.

d. Data Required. The data required are the amount of look angle change (gyro drift) during the time period of the subtest and an extrapolation of the data to apply to a time period of one hour. Enter the results in the master log book. Annotate the graph with the seeker identification and other pertinent information and insert in the test data package. This test will be performed one time on each seeker in each group (15 total). Accuracy of measurement will be plus or minus one percent.

e. Analytical Plan. Evaluate the effects of any detectable gyro drift on in-flight performance of the seeker considered in conjunction with the field-of-view (paragraph 14), static gain (paragraph 16), and tracking capability (paragraph 20).

12. Signal-to-Noise Ratio.

a. Objective. Determine the infrared energy level required to cause the signal plus noise to be twice the value of the noise alone.

b. Standards. None applicable.

c. Method. (see paragraph 31).

(1) Apply power to the seeker and cover the optics to block infrared energy from the detector. Apply power to energize the seeker detector cooling, as applicable.

(2) Connect the VTVM, adjusted to a suitable scale, to measure the output of the detector preamplifier or other point in the electronics not affected by Automatic Gain Control (AGC) action. Refer to figure 5 for instrumentation and connections.

(3) Note and record the output as indicated by the VTVM; this is the dark-cell noise of the seeker.

(4) Remove the cover from the seeker optics and allow infrared energy from the collimated source to irradiate the seeker optics; uncage the gyro.

(5) Adjust the temperature of the black body, the diameter of the exit aperture, and the infrared attenuators, as required, to irradiate the seeker optics with that amount of energy required for the VTVM reading to be exactly twice as great as the reading obtained for dark-cell noise.

(6) Using the information determined in step (5) and the table of black body radiation functions (appendix A, reference 1), calculate the amount of infrared energy impinging on the seeker optics required for a signal plus noise-to-noise ratio of 2 to 1. This is the threshold level of broad band radiant intensity required for dependable operation of the seeker.

NOTE: Broad band radiant intensity is not directly relatable to energy emitted from a realistic infrared target which emits in lines and bands with spectral distribution of an unknown nature.

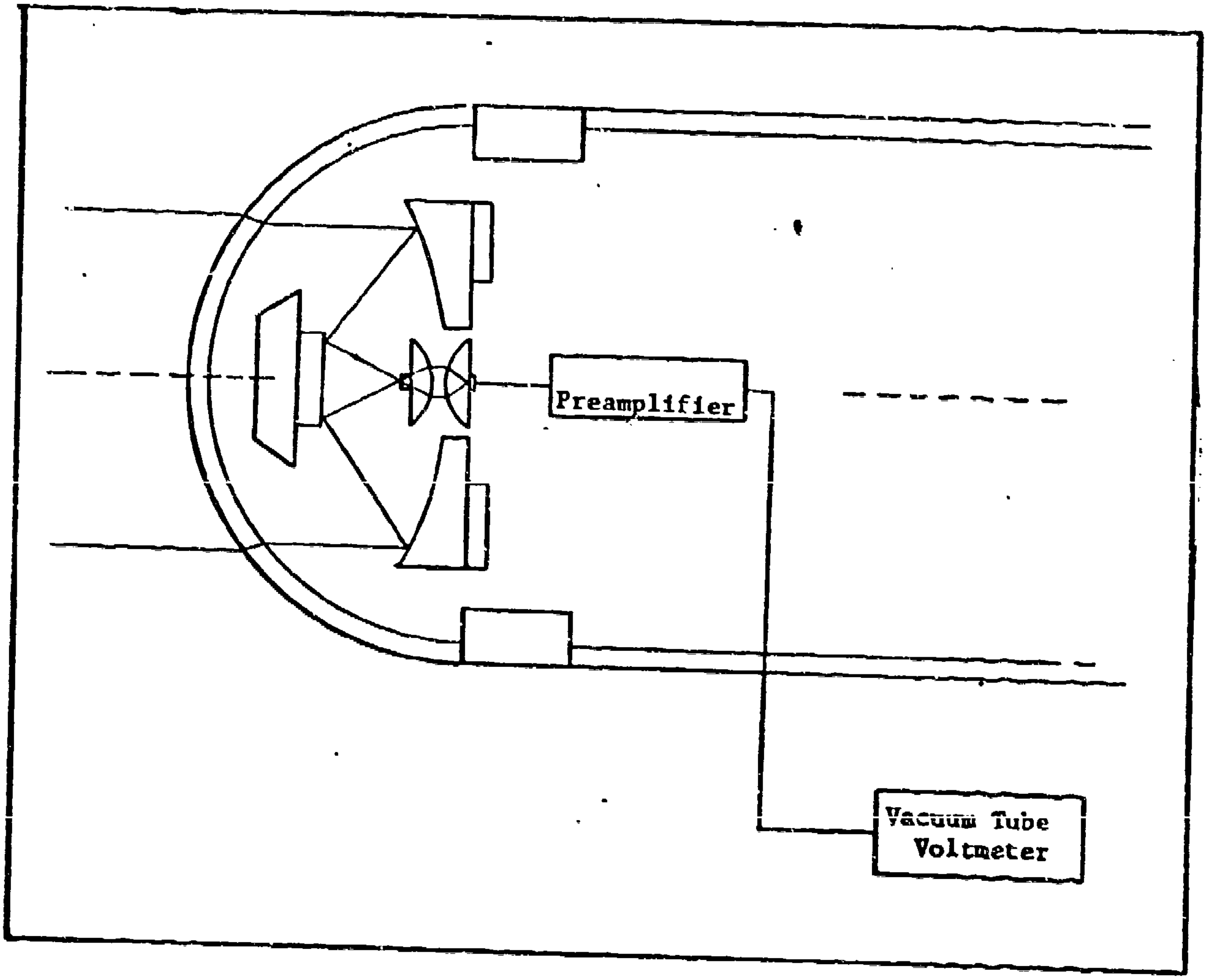

Figure 5. Signal-to-Noise Ratio.

d. Data Required. The data required are the VTVM reading for dark-cell noise of the detector with accuracy of plus or minus 0.5 percent and the infrared energy level, in watts per unit area of the collecting optics, as calculated from c(6) above. The infrared energy level will be referenced back to the black body unpolarized emittance expressed in watts per square centimeter per steradian. All calculations will be shown, including values for the diameter of the exit aperture, the attenuation of each neutral density filter, and the focal length of the collimating mirror with its percentage of reflectance. This subtest will be performed one time on each seeker in each group (15 total).

e. Analytical Plan. Compare the dark-cell noise figure and the calculated infrared levels to like values specified in the requirements document and determine the degree by which the seeker meets the requirements.

13. Cool-Down Time.

a. Objective. Determine the amount of time required for the infrared detector to cool down to its operating temperature.*

b. Standards. The time required for the detector to cool down to its operating temperature shall not be greater than the time required for the gyro to spin up to specified operating speed.

c. Method. (See paragraph 31).

(1) Use the same test equipment and connections as in paragraph 12 (signal-to-noise ratio subtest). Adjust the infrared source to output the same level of energy as determined in paragraph 12c(6). Position the source at zero look angle.

(2) Apply power to the seeker and allow the gyro to spin up to its operating speed.

(3) Simultaneously start the timer and apply power to energize the detector cooling. Observe the reading on the VTVM.

(4) When the VTVM reading reaches the value of twice the dark-cell noise, stop the timer.

(5) Read the elapsed time and enter in the master log book as cool-down time.

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*Omit this subtest for seekers which operate with uncooled detector.

d. Data Required. The data required is the time in seconds as read from the elapsed time meter required for the detector cooling to reduce the temperature of the detector to its operating temperature. Accuracy of measurement shall be plus or minus one percent. This subtest will be performed one time on each seeker in each group (15 total).

e. Analytical Plan. Compare the measured cool-down time with the specified cool-down time in the requirements document and determine the percentage by which the seeker meets requirements; compare the measured time to the spin-up time measured in paragraph 5 and determine the percentage by which the seeker meets the standards.

14. Field-of-View.

a. Objective. Determine the instantaneous field-of-view of the infrared detector "looking through" the gyro-optical system of the seeker.

b. Standards. None applicable.

c. Method.

(1) Connect the Y-axis of the X-Y recorder to indicate the output of the detector preamplifier or other point in the electronics not affected by AGC action. Connect the X-axis of the recorder to indicate the look-angle position of the collimated infrared source. Adjust the recorder so that zero look angle is indicated in the center of the X-axis. Refer to figure 6 for instrumentation and connections.

(2) Connect the VTVM to indicate the output of the detector preamplifier.

(3) Apply power to the seeker and adjust the infrared source for irradiation of the seeker optics with the energy level required for a signal-to-noise ratio of 2:1 as indicated by the VTVM. (see paragraph 12c(5) above).

(4) Apply power to energize detector cooling; do not uncage the gyro.

(5) Lower the pen of the recorder and energize the look-angle drive to move the collimated infrared source clockwise at 0.1 degrees per second. As the look angle increases, the Y-axis of the X-Y recorder will increase to the peak and then decrease to zero when the source passes out of the field-of-view of the seeker. When the curve is completed, lift the pen of the X-Y recorder and return the infrared source to zero look angle.

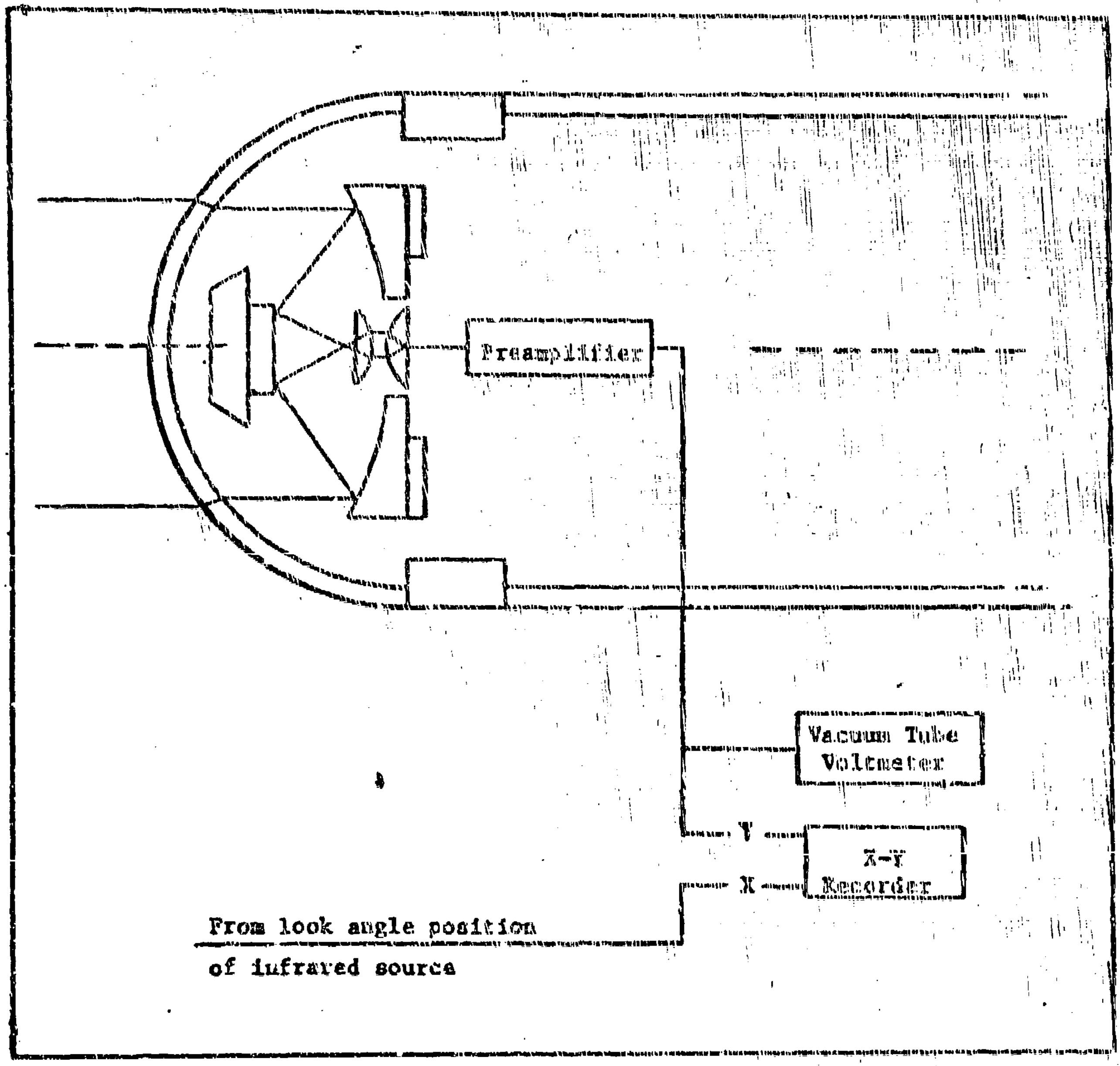

Figure 6. Field-of-View.

(6) Repeat step (5) with the look angle increasing counterclockwise from center to complete the other half of the graph. (Refer to figure 7 for typical curve).

(7) Lift the recorder pen; turn off power to the seeker and zero the look-angle drive. Remove the graph paper from the X-Y recorder.

(8) Examine the graph just completed and determine the value of the maximum voltage at each of the (major) peaks; one on each side of center. If the peaks are not the same value, find the average of the two and call this "peak voltage". Find the points on the graph (there will be at least two on each half of the graph paper) where the Y-axis voltage is equal to one-half the value of "peak voltage". Determine the distance in degrees between the two points just found; this is the instantaneous field-of-view of the seeker detector.

(9) Enter the value found for the field-of-view in the master log book. Annotate the graph paper for seeker identification and any other pertinent information and add it to the test data package.

d. Data Required. The data required is the instantaneous field-of-view of the infrared detector expressed in degrees with accuracy of plus or minus 0.05 degrees. This subtest will be performed one time on each of three seekers (A_1, B_1, and C_1).

e. Analytical Plan. Compare the measured field-of-view with the field-of-view specified in the requirements document and determine the percentage by which the seeker meets the requirement.

15. Caging Accuracy.

a. Objective. Determine the accuracy with which the gyro caging mechanism aligns the axis of the gyro with the longitudinal axis of the seeker.

b. Standards. None applicable.

c. Method.

(1) Connect the Y-axis of the X-Y recorder to indicate the output of the detector preamplifier or other point in the electronics not affected by AGC action. Connect the X-axis of the recorder to indicate the look-angle position of the collimated infrared sources. Adjust the recorder so that zero look angle is indicated in the center of the X-axis. Refer to figure 6 for instrumentation and connections.

(2) Connect the VTVM to indicate the output of the detector preamplifier.

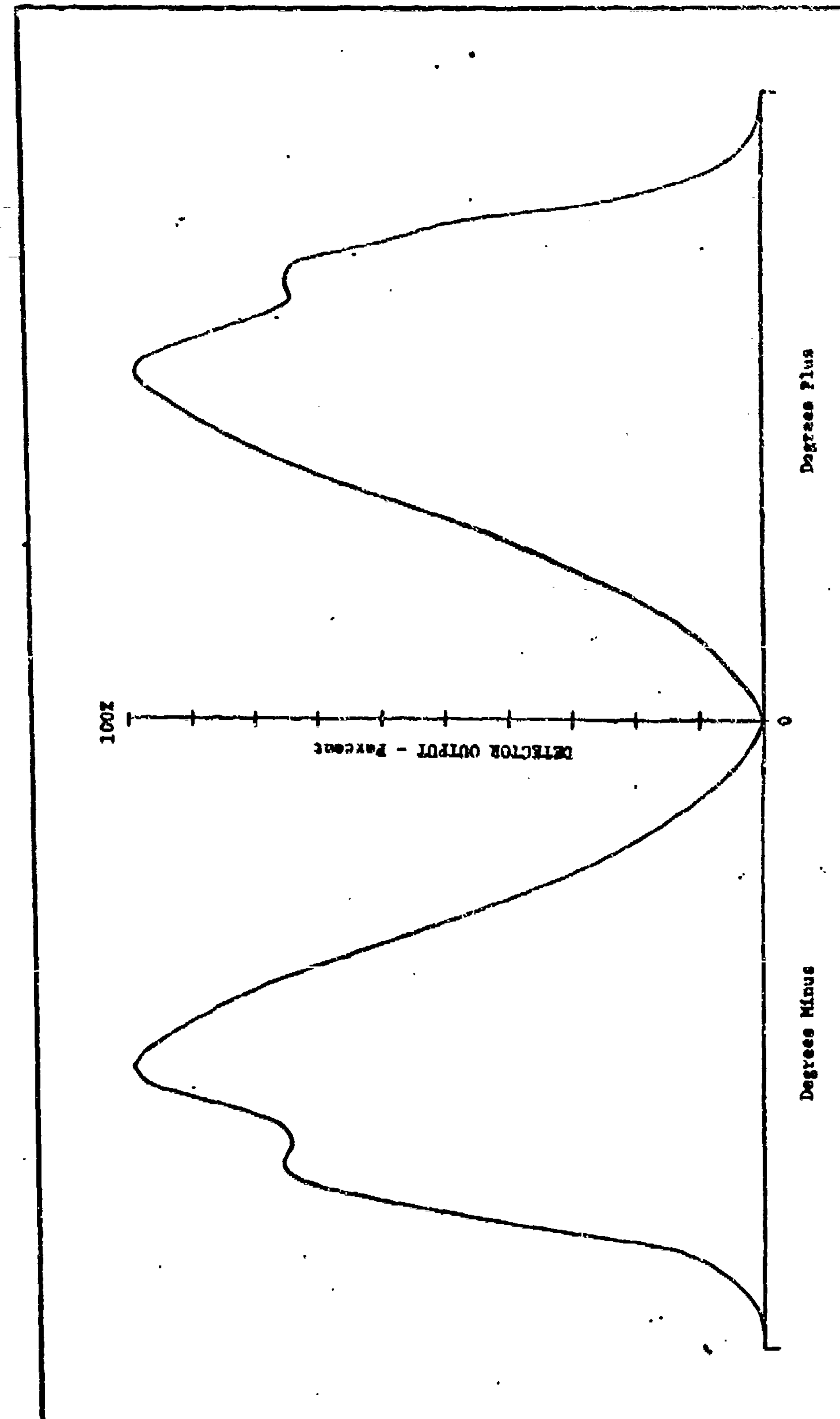

Figure 7. Simulated Curve Representing Typical Static Gain.

(3) Make substitutions in attenuators or black body apertures (or both) as required to provide irradiation of the seeker optics with four times as much infrared energy as is required for a signal-to-noise ratio of 2:1.*

NOTE: The amount of energy required cannot be determined by means of the VTVM readings, however, the VTVM shall be observed to assure that AGC action does not prevent an increase in detector output for an increase in infrared input.

(4) Apply power to the seeker and allow the gyro to spin up to its operating speed; enable detector cooling; do not uncage the gyro.

(5) Energize the look-angle drive and position the infrared source at a clockwise look angle greater than one-half the field-of-view determined in paragraph 14.

(6) Lower the pen of the X-Y recorder and drive the infrared source counterclockwise at 0.5 degree per second to a counterclockwise look angle greater than one-half the field-of-view. The X-Y recorder will draw a graph similar to that obtained in paragraph 14c(6) except that the middle dip may not be in the center of the X-axis of the graph.

(7) Lift the recorder pen, stop the look-angle drive, turn off power to the seeker, and remove the graph paper from the recorder.

(8) Examine the graph just completed and determine how far, if at all, the middle dip is offset (in degrees) from the center of the X-axis of the graph.

(9) Rotate the seeker 10 degrees about its longitudinal axis and repeat steps (4) through (8). Repeat this step until the seeker has been rolled through 350 degrees.

(10) Locate the two graphs which show the middle dip offset from center by the largest amount; one will be offset to the right and one will be offset to the left; the two graphs will correspond to roll positions separated by 180 degrees. The absolute value of the offset should be equal; if not, find the average (disregarding direction of offset) of the two values; this is the caging accuracy of the gyro; enter this number in the master log book. Annotate the graphs with seeker identifications and other pertinent information and add them to the test data package.

d. Data Required. The data required is the caging accuracy of the seeker, expressed in degrees with accuracy of plus or minus one percent. This subtest will be performed one time on each of three seekers (A_1, B_1, and C_1).

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*DO NOT change the temperature of the black body in the collimated infrared source.

e. Analytical Plan. Compare the measured caging accuracy to the specified caging accuracy in the requirements document and determine the percentage by which the seeker meets the requirements.

16. Static Gain.

a. Objective. Determine the static gain characteristics (volts per degree) of the seeker by measuring the detector output (in volts) for various pointing error (in degrees) within the limits of the instantaneous field-of-view of the detector.

b. Standards. None applicable.

c. Method.

(1) Locate the graph made in the field-of-view subtest (paragraph 14), and determine the average slope of the curve from zero to maximum in each direction from the center of the X-axis. Using a straight edge, draw a line to represent the slope of the actual curve as produced by the X-Y recorder.

(2) Express the slope of each straight line as volts per degree; find the average of the two and enter in the master log book.

(3) Repeat the procedure in steps (1) and (2) for each curve obtained in the caging accuracy subtest (paragraph 15) and enter the results in the master log book.

(4) Find the average of all the slopes so far determined and enter this number in the master log book as the average static gain of the seeker expressed in volts per degree.

(5) In some applications involving computer programming, it is more desireable to have access to the actual slope rather than the average slope; therefore, the original graphs shall be preserved for inclusion in the report of test.

d. Data Required. The data required are the values of the maximum slope, minimum slope, and average of all the slopes of detector output versus pointing error exessed as volts per degree. The value of the average slope is the average static gain of the seeker. The graphs will be preserved for possible use in those computer operations which require the instantaneous static gain as a function of pointing error. Accuracy of measurement shall be plus or minus one percent.

e. Analytical Plan. The average static gain will be compared to the static gain specified in the requirements document and the percentage by which the seeker meets requirements will be compared to the tolerances specified in the requirements document and the significance of variations from requirements will be evaluated.

17. Spectral Responsivity.

a. Objective. Determine the response of the seeker (volts output) to infrared energy input (irradiation on the seeker for optics) as a function of wavelength within the wavelength passband of the seeker.

b. Standards. None applicable, except that the half-power points may be given in the requirements document as the short wavelength and long wavelength limits of the infrared passband of the seeker.

c. Method.

(1) Remove the seeker and its holding fixture from the rate table and mount them so that the seeker optics are irradiated by the beam of collimated infrared energy from the infrared signal generator.

(2) Connect the VTVM to measure the output of the detector preamplifier as in paragraph 12c(2). Adjust the wavelength and amplitude of the infrared generator such that the seeker is irradiated with energy in its passband and the output of the seeker is the same as in paragraph 12c(5).

(3) Connect the seeker output to the automatic amplitude control input of the generator so that the infrared output will be adjusted to keep the seeker output constant with changes in wavelength of the infrared generator.

(4) Connect the output voltage of the infrared generator (which is proportional to amplitude of the infrared output) to the Y-axis input of the X-Y recorder. Connect the wavelength-drive voltage output of the generator to the X-axis of the X-Y recorder.

(5) Connect the magnetic tape recorder so that the voltages appearing at the X and Y inputs of the X-Y recorder will be recorded on channels 1 and 2, respectively, of the tape recorder.

(6) Connect the power supply and relay amplifier so that a one-volt d.c. level will be recorded on channel 3 of the magnetic tape recorder whenever the detector output exceeds 75 percent of the value of voltage determined in step (2) above. Refer to figure 8 for instrumentation and connections.

(7) Apply power and cooling to the seeker and allow the gyro to spin up to its regulated operating speed. Set the wavelength of the infrared generator just outside the passband of the seeker.

(8) Energize the automatic wavelength drive of the infrared generator and allow it to scan through the infrared passband of the seeker. Lower pen of the X-Y recorder. Start the magnetic tape recorder in record mode at 15 inches per second.

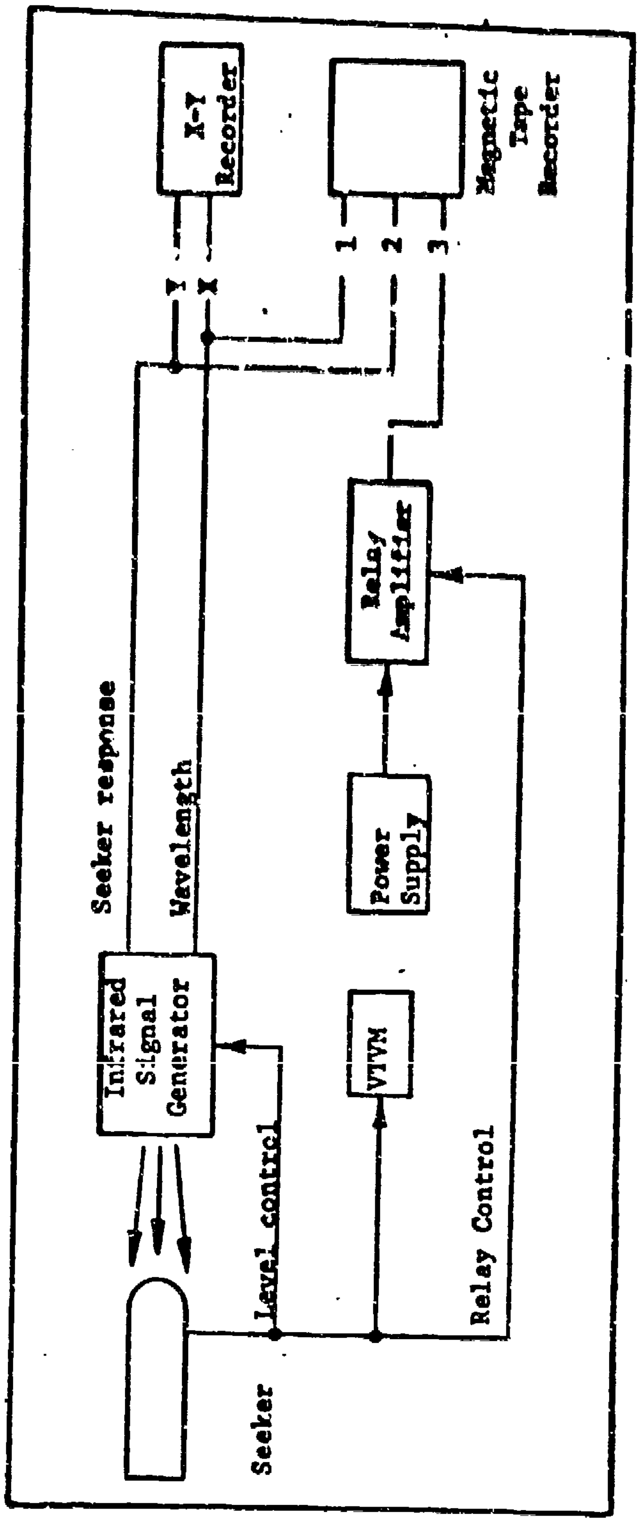

Figure 8. Instrumentation Connections for Spectral Responsivity.

(9) Apply power to the seeker holding fixture to roll the seeker at its nominal roll rate as specified in the requirements document. Omit this step when testing seekers which are used with missiles that do not roll during flight.

(10) Uncage the gyro when the infrared generator outputs energy within the passband of the seeker as indicated by an increase in the reading of the VTVM.

(11) Observe the VTVM during the remainder of the subtest to assure that the voltage output of the seeker remains at the value set in step (2) above. The X-Y recorder and the magnetic tape recorder will record the inverse of the seeker response curve versus wavelength across the infrared passband of the seeker. The magnetic tape recorder will, additionally, record a signal between the half-power points thereby identifying the short wavelength and long wavelength limits of the infrared passband of the seeker.

(12) When the graph is finished; lift the pen of the X-Y recorder, cage the gyro, turn off power to the infrared generator, the recording equipment, and the seeker.

(13) Rewind the magnetic tape recorder.

(14) Remove the graph from the X-Y recorder and mark the short and long wave limits of the passband of the seeker as λ_1 and λ_2 respectively.

(15) In the Table of Blackbody Radiation Functions (appendix A, reference 1), find the black body temperature which was determined in paragraph 12c(5) and read the value of the integral of $N_\lambda d_\lambda$ between the wavelengths determined in step (14); find the wavelength of peak radiation and the value of the radiation at this wavelength; also, find the value of radiation at each tenth-micron interval from λ_1 to λ_2. Plot the black body output curve on two-cycle semilog graph paper with linear X-axis. See figure 9 for an example of a typical curve.

(16) Connect the reproduce output number 1 of the magnetic tape recorder to drive the arbitrary function generator (AFG), the X-axis of X-Y recorder #1, and the X-axis of X-Y recorder #2. (see figure 10.) Connect output number 3 of the tape recorder to the integrating digital voltmeter (IDVM) so that the one-volt level recorded in step (11) will enable the integrate function of the IDVM between λ_1 and λ_2.

(17) Connect the output of the AFG to the input of operational amplifier number 1 (Op Amp #1); the output of the Op Amp #1 to the input

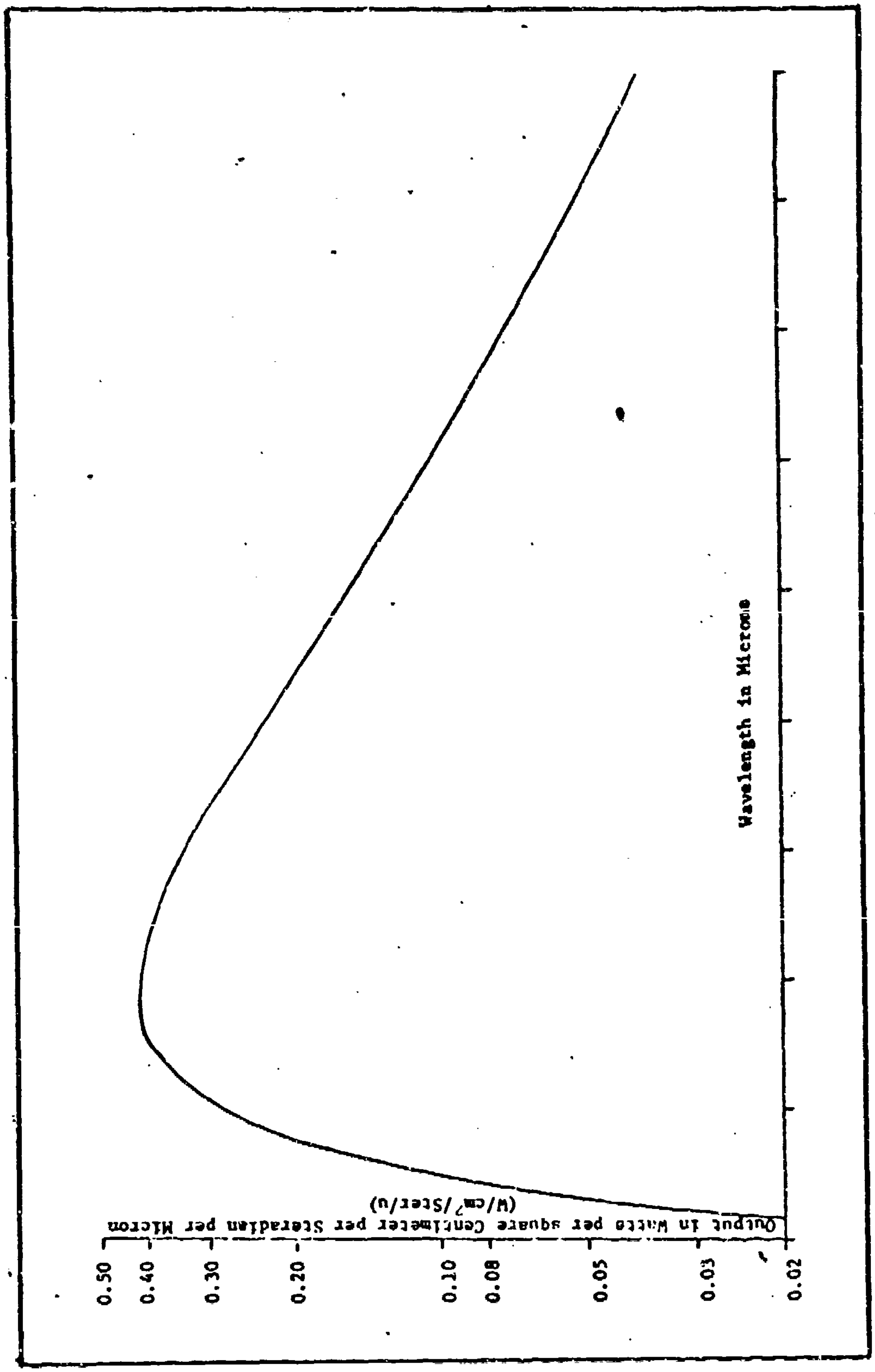

Figure 9. Spectral Emittance of a Blackbody at Temperature of 1,000° Kelvin.

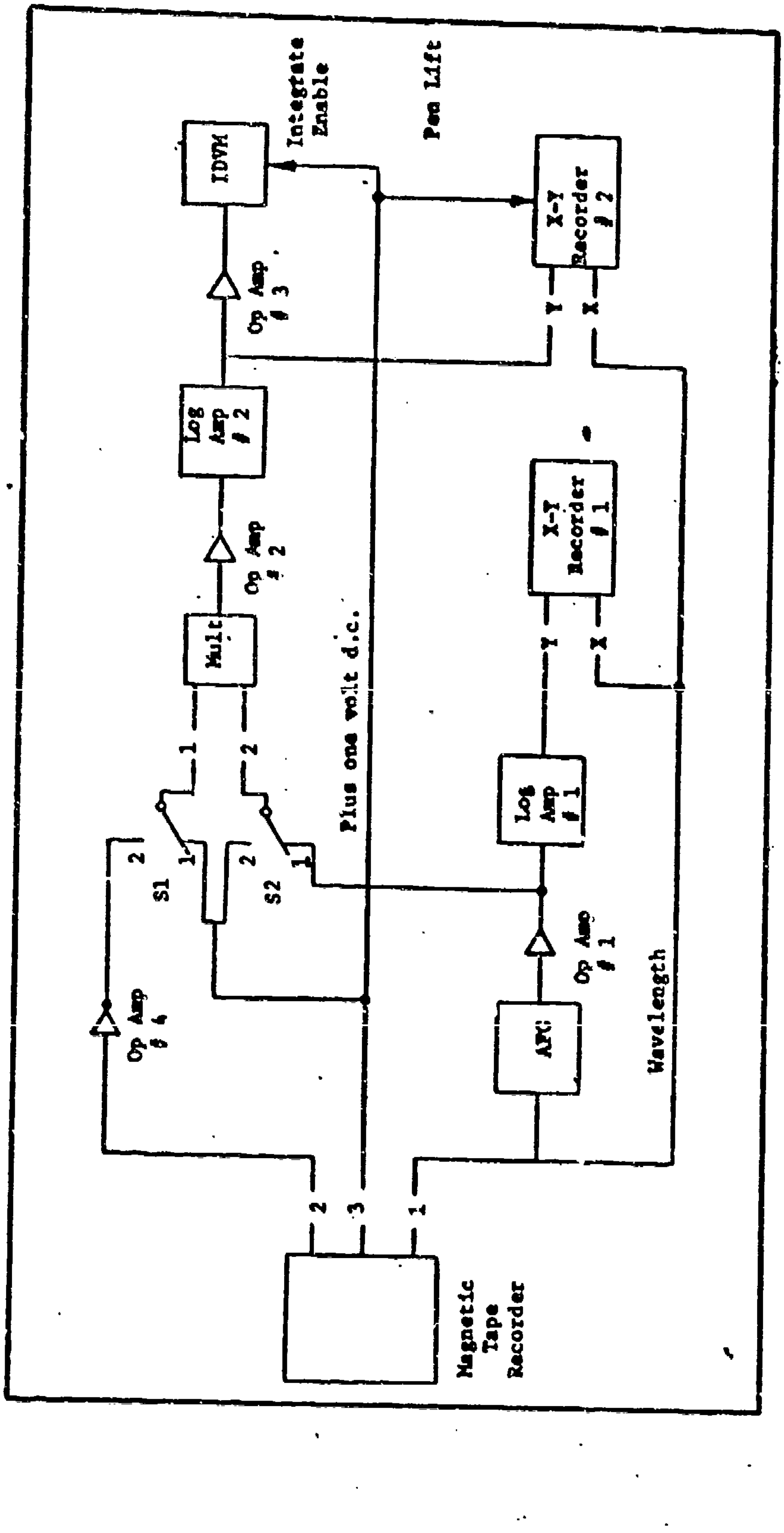

Figure 10. Instrumentation Connections for Spectral Responsivity and Intercept Ability.

of logarithmic amplifier number 1 (Log Amp #1); and the output of Log Amp #1 to the Y-axis input of X-Y recorder #1. Connect the output of Op Amp #1 also to input #2 of the voltage multiplier through switch S2 in position 1.

(18) Connect output #3 of the tape recorder to input #1 of the multiplier through S1 in position 1. Connect the output of the multiplier to input of Op Amp #2 and the output of Op Amp #2 to the input of Log Amp #2. Connect the output of Log Amp #2 to the Y-axis input of X-Y recorder #2.

(19) Connect the output of Log Amp #2 to the input of Op Amp #3 and the output of Op Amp #3 to the input of the IDVM. (The output of Op Amp #3 is the voltage to be integrated by the IDVM during integrate enable period, between λ_1 and λ_2.)

(20) Connect the integrate enable line (output #3 of the tape recorder) to the pen lift circuitry of X-Y recorder #2 so that the X-Y recorder will write only when the tape recorder is reproducing the information recorded between λ_1 and λ_2.

(21) Locate the black body curve which was plotted in step (15) and place it on X-Y recorder #1.

(22) Energize the tape recorder and reproduce the tape which was recorded in step (11). While the tape is playing, adjust the AFC and the gain of Op Amp #1 so that X-Y recorder #1 will retrace the pre-plotted black body curve; rewind the tape recorder.

(23) Repeat step (22) and adjust the multiplier and the gain of Op Amp #2 so that X-Y recorder #2 draws (from λ_1 to λ_2 only) the curve which is plotted in step (15). Since the output of the multiplier is the product of the output of Op Amp #1 times one volt from output #3 of the tape recorder, the voltage at the Y input of X-Y recorder #2 should be identical to that at the Y input of X-Y recorder #1.

(24) Repeat step (22) and adjust the IDVM and the gain of Op Amp #3 so that the IDVM will accumulate a value of volt-seconds equal to the numerical value of the integral determined in step (15) in watts. The operation of the system of figure 9 is such that X-Y recorder #2 will draw the curve of spectral emittance of the black body used in the subtest of paragraph 12 (signal-to-noise ratio) with accurate calibration of the Y-axis in watts per square centimeter per steridian per micron, and wavelength in microns on the X-axis; also, the IDVM will read the value of the area under the curve in watts per square centimeter incident on the dome of the seeker.

(25) Connect output #2 of the tape recorder to the input of Op Amp #4 which is an inverting amplifier, the output of which is the spectral response of the seeker. Connect the output of Op Amp #4 to input #1 of the multiplier through S1 in position #2.

(26) Repeat step (22) and adjust the gain of Op Amp #4 such that the IDVM will accumulate the same value of volt-seconds as in step (24). The curve plotted on X-Y recorder #2, using the same calibration for the Y-axis as in step (23), will show the amount of infrared energy at each wavelength which is required for a 2 to 1 signal plus noise-to-noise ratio.

d. Data Required. The data required are the graph of seeker responsivity in terms of the level of infrared energy in watts per unit area on the optics required at each wavelength for a signal plus noise-to-noise ratio of 2 to 1; also required are the wavelengths of the half-power points (λ_1 to λ_2) which establish the limits of detector sensitivity. This subtest will be conducted one time on each of the seekers (15 total). Accuracy of measurement shall be plus or minus five percent.

e. Analytical Plan. Compare the measured half-power points to the wavelength limits specified in the requirements document; determine the degree by which the seeker meets the requirements. The graph of spectral responsivity will be used in a later subtest in conjunction with measured data from tactical targets to determine which of those targets can be acquired and tracked by the seeker.

18. Intercept Ability.

a. Objective. Determine the ability of the seeker to acquire and track a given infrared target under specified conditions of weather and geographical locations.

b. Standards. None applicable.

c. Method.

(1) Use the same instrumentation and connections shown in figure 10 for subtest 17.

(2) Obtain a graph of the spectral emittance of the given infrared tactical target and place it on X-Y recorder #1.

(3) Turn on the tape recorder and reproduce the tape which was recorded in step (11), paragraph 17c; adjust the AFG to reproduce the curve on X-Y recorder #1.

(4) Rewind the tape recorder.

(5) With S1 in position 2 and S2 in position 1, play the tape recorder and observe the IDVM reading accumulation between λ_1 and λ_2.

(6) Rewind the tape recorder and note the reading of the IDVM; if it indicates a value larger than the value obtained in step (24), paragraph 17c, the output of the tactical target under consideration is greater than that required for a signal plus noise-to-noise ratio of 2 to 1 at the dome of the seeker and the seeker will acquire and track that target under the atmospheric conditions at the time of measurement of the target.

(7) Repeat step (3) and adjust the A/G to introduce additional attenuation in the target emittance to simulate effects of range, weather conditions, and geographical location as required.

(8) Repeat steps (4) through (6) and evaluate the effect on signal plus noise-to-noise ratio resulting from changes made in step (7).

(9) Repeat steps (7) and (8) as required to satisfy any requirements for evalution of intercept ability.

d. Data Required. The data required are a list of tactical targets and conditions of operation on each which provide a signal plus noise-to-noise ratio of 2 to 1 or greater in the seeker. Also required is a list of conditions, for otherwise suitable targets, under which the seeker will not acquire and track satisfactorily. This subtest does not require additional seeker operating time; it is performed using data recorded in the previous subtest. Accuracy of measurement shall be plus or minus five percent.

e. Analytical Plan. The data collected from testing in the laboratory will be used to determine the course and degree of testing in the field. It can be determined in the laboratory which targets and under what conditions the seeker can acquire and track. The data will also be used to establish the requirements for simulating tactical infrared targets for further laboratory and field testing.

19. <u>Gyro Spin versus Slew Rate</u>.

a. Objective. Determine the effect of slew rate on gyro spin frequency at various look angles.

b. Standards. None applicable.

c. Method.

(1) Connect the X-Y recorder so that gyro spin frequency is displayed on the Y-axis and the X-axis is driven by the internal time base generator. Also connect the output of the detector preamplifier

so that the presence of acquisition signal will lower the pen of the recorder; loss of the target will cause the pen to raise and stop writing.

(2) Adjust the attenuators in the infrared source to provide the same amount of energy to the seeker as was used in paragraph 15c(3).

(3) Apply power to the seeker and allow the gyro to spin up to its regulated value; uncage the gyro when it acquires the target.

(4) Energize the look angle drive and position the target at 20 degrees clockwise from the longitudinal axis of the seeker.

(5) Select an acceleration rate of 10 degrees per second per second for the rate table and velocity of ten degrees per second; select an appropriate time scale for the X-axis of the X-Y recorder.

(6) Turn off power to the gyro drive circuitry. Omit this step if the seeker normally flies with gyro spin power on.

(7) Simultaneously start the rate table turning clockwise and energize the X-axis drive of the X-Y recorder. The X-Y recorder will draw a graph of gyro spin frequency change with time. Allow the test to continue until the seeker loses track of the target or until the spin frequency stabilizes at some constant value.

(8) When the graph is finished, stop the rate table; turn off the X-Y recorder; turn off power to the seeker; reset the look angle to zero.

(9) Remove the graph paper from the X-Y recorder and annotate it with rate table acceleration and velocity, look angle, seeker identification, and other pertinent information.

(10) Put new graph paper on the X-Y recorder and repeat steps (3) through (9) seven times using rate table velocities of 0.5, 1.0, 2.0, 4.0, 8.0, 15.0, and 20.0 degrees per second. See figure 11 for simulated representation of the family of curves to be expected.

(11) Repeat step (10) five times with look angles of zero, 5.0, 10.0, 15.0, and 30 degrees clockwise.

(12) Repeat step (11) with the rate table turning counterclock - wise in each instance.

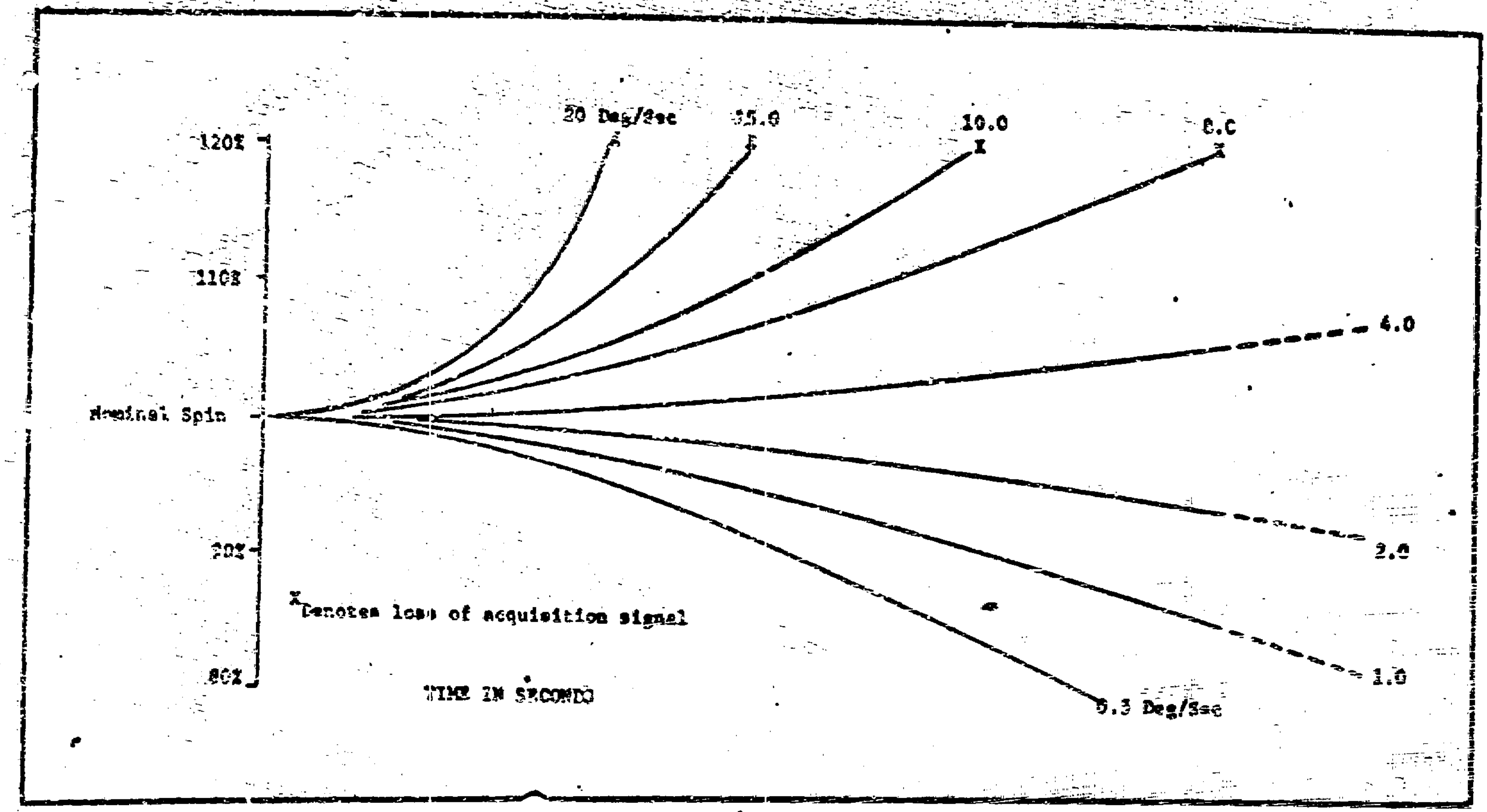

Figure 11. Simulated Family of Curves Similar to What Is to Be Expected from Paragraph 19 Subtest.

d. Data Required. The data required are a graph showing the effect of slew rate on gyro spin for each condition of look angle and for each acceleration rate of the rate table. The length of time that the seeker will track at each of the 96 conditions shall be extracted from the graphs for use with the test data from the subtest of paragraph 20. Accuracy of measurement shall be plus or minus 0.5 percent. This subtest shall be performed on three seekers (A_1, B_1, and C_1).

e. Analytical Plan. Limitations to tracking ability imposed by time and gyro spin frequency will be analyzed in conjuction with results from other subtests to determine the overall performance characteristics of the seeker during flight.

20. Maximum Tracking versus Gyro Spin.

a. Objective. Determine the maximum tracking rate at 2:1 signal-to-noise ratio and various look angles.

b. Standards. None applicable.

c. Methods.

(1) Connect the X-Y recorder so that gyro spin frequency is displayed on the Y-axis and the X-axis is driven by the internal time base generator. Also connect the output of the detector preamplifier so that the presence of acquisition signal will lower the pen of the recorder; loss of the target will cause the pen to raise and stop writing.

(2) Adjust the attenuators in the infrared source to provide the same amount of energy to the seeker as was used in paragraph 12 (Signal-to-Noise Ratio).

(3) Apply power to the seeker and allow the gyro to spin up to its regulated value; uncage the gyro when it acquires the target.

(4) Energize the look angle drive and position the target at 20 degrees clockwise from the longitudinal axis of the seeker.

(5) Select an acceleration rate of 0.5 degree per second per second for the rate table; select an appropriate time scale for the X-axis of the X-Y recorder.

(6) Turn off power to the gyro spin circuitry.*

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*Omit this step if the seeker normally flies with gyro spin power on.

(7) Simultaneously start the rate table turning clockwise and energize the X-axis of the X-Y recorder. The X-Y recorder will draw a graph of the gyro spin frequency versus time and tracking rate which can be calculated from the time scale on the X-axis.

(8) Allow the rate table to accelerate until the seeker loses track of the target; the X-Y recorder pen will lift at loss of track.

(9) When the graph is finished, cage the gyro; stop the rate table; turn off the X-Y recorder; reset the look angle to zero; turn off power to the seeker.

(10) Remove the graph paper from the X-Y recorder and annotate it with acceleration of the rate table, look angle, seeker identification, tracking rate and gyro spin frequency at loss of track, the level of infrared energy on the dome, and any other pertinent information.

(11) Put new graph paper on the X-Y recorder and repeat steps (3) through (10) seven times using acceleration rates of 1.0, 2.0, 4.0, 8.0, 10.0, 15.0, and 20.0 degrees per second per second for the rate table.

(12) Repeat step (11) five times with look angles of zero, 5.0, 10.0, 15.0, and 30 degrees clockwise.

(13) Repeat step (12) with the rate table operating counterclockwise for each graph.

d. Data Required. The data required are the maximum tracking rate capability of the seeker as a function of look angle and a graph showing the length of time (in seconds) that the seeker can be expected to track at a given rate in degrees per second. Accuracy of measurement shall be plus or minus 0.5 percent. This subtest shall be performed on three seekers (A_1, B_1, and C_1).

e. Analytical Plan. The maximum tracking rate of the seeker shall be determined as a function of gyro spin frequency as it is affected by look angle and tracking time at any given rate of track. This information shall be determined for clockwise and counterclockwise tracking directions. Compare the results of this subtest and those from paragraph 19 to the maximum rate stated in the requirements document, and determine the percentage by which the test item meets the requirement.

21. Maximum Tracking Rate versus Target Intensity.

a. Objective. Determine the minimum level of infrared energy required for dependable operation of the seeker in acquisition and tracking a target.

b. Standards. None applicable.

c. Method.

(1) Use the same instrumentation and connections as in paragraph 20.

(2) Add attenuation to the collimated infrared source (do not reduce the temperature of the black body) to reduce the level of infrared energy impinging on the seeker dome.

(3) Perform steps (3) and (13)* of paragraph 20c and note the percent of degradation in tracking ability caused by reduction in infrared energy to the seeker.

(4) Repeat steps (2) and (3), adding more infrared attenuation each time, until the performance of the seeker is judged to be reduced by 50 percent of its capability as established in paragraph 20c.

(5) Determine the signal plus noise-to-noise ratio of the seeker when irradiated with the energy level established in step (4).

d. Data Required. The data required are the values of infrared energy required for operation of the seeker at 50 percent of its capability with sufficient energy for a signal plus noise-to-noise ratio of 2 to 1; and the signal plus noise-to-noise ratio when operating with this reduced energy. Accuracy of measurement shall be plus or minus 10 percent. This subtest shall be performed on three seekers (A_1, B_1, and C_1).

e. Analytical Plan. Compare the minimum energy value determined in step (4) to the minimum value specified in the requirements document and determine the percentage by which the test item meets the requirements. Using the results from this subtest and those from paragraphs 18, 19, and 20, determine realistic engagement boundaries for the seeker against tactical targets as a function of airspeed, slant range, flight path (whether left to right crossing or right to left), measured infrared output of the target, and the length of time the seeker can be expected to track the target.

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*Steps (11) and (12) or portions thereof may be omitted at the discretion of the test conductor.

22. Low Temperature Storage.

a. Objective. Determine the operational capability of the seeker after storage at low temperature.

b. Standards. None applicable.

c. Method.

(1) Perform a Satisfactory Performance Test (SPT)* on the seeker to determine its operational readiness.

(2) Prepare the seeker for prolonged low temperature storage according to the technical manuals, maintenance procedures, and other instructions and subject the seeker to the required low temperature conditions as described in MTP 5-2-583.

(3) Remove the seeker from low temperature environment and return it to laboratory ambient conditions; perform an SPT to determine whether any operational and physical degradation has resulted from the environment.

d. Data Required. The data required are results of the pre- and post low temperature storage SPT and the degree of degradation to the seeker, if any, caused by the environment. This subtest will be performed one time on each of the seekers in group D.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

23. Low Temperature Operate.

a. Objective. Determine the operational capability of the seeker in low temperature environment.

b. Standards. None applicable.

c. Method.

(1) Install the seeker in the seeker holding fixture on the rate table; attach the low temperature shroud to surround the seeker.

(2) Perform a pre-environment SPT on the seeker to determine its operational readiness.

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*See paragraph 32.

(3) Lower the temperature inside the environmental shroud according to MTP 5-2-583 to the level specified in the requirements document. When the seeker has stabilized at the low temperature, perform an SPT.

(4) Return the seeker to laboratory ambient conditions according to instructions in applicable documents and perform a post-environmental SPT.

d. Data Required. The data required are the results of the pre-environmental SPT, the SPT performed during the environment, and the post-environment SPT. Also required is the degree of operational degradation to the seeker at low temperature and any residual effects during the post-environmental SPT at laboratory conditions. This subtest will be performed one time on each of the seekers in group E.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

24. High Temperature Storage.

a. Objective. Determine the operational capability of the seeker after storage at high temperature.

b. Standards. None applicable.

c. Method.

(1) Perform an SPT on the seeker to determine its operational readiness.

(2) Prepare the seeker for prolonged high temperature storage according to the technical manuals, maintenance procedures, and other instructions and subject the seeker to the required high temperature conditions as described in MTP 5-2-594.

(3) Remove the seeker from high temperature environment and return it to laboratory ambient conditions; perform an SPT to determine whether any operational and physical degradation has resulted from the environment.

d. Data Required. The data required are results of the pre- and post-environment SPT and the degree of degradation to the seeker, if any, caused by the environment. This subtest will be performed one time on each of the seekers in group E.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirement.

25. High Temperature Operate.

a. Objective. Determine the operational capability of the seeker in high temperature environment.

b. Standards. None applicable.

c. Method.

(1) Install the seeker in the seeker holding fixture on the rate table; attach the high temperature shroud to surround the seeker.

(2) Perform a pre-environmental SPT on the seeker to determine its operational readiness.

(3) Raise the temperature inside the environmental shroud according to MTP 5-2-594 to the level specified in the requirements document. When the seeker has stabilized at the low temperature, perform an SPT.

d. Data Required. The data required are the results of the pre-environmental SPT, the SPT performed during the environment, and the post-environmental SPT. Also required is the degree of operational degradation to the seeker at high temperature and any residual effects during the post-environmental SPT at laboratory conditions. This subtest will be performed one time on each of the seekers in group D.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

26. Transportation Vibration.

a. Objective. Determine the operational capability of the seeker after simulated transportation vibration environment.

b. Standards. None applicable.

c. Method.

(1) Perform a pre-environmental SPT on the seeker to determine its operational readiness.

(2) Prepare the seeker for shipment according to technical manuals, maintenance procedures, and other instructions using the specified transport mode tie-down configuration for each mode to be simulated as indicated in the requirements document.

(3) Subject the seeker to simulated transportation vibration using shake tables as required with random vibration input data empirically determined from field measurements.

(4) Remove the seeker from the environment and return it to laboratory ambient conditions; perform an SPT to determine whether any operational and physical degradation has resulted from the environment.

d. Data Required. The data required are results of the pre- and post-environment SPT and the degree of degradation to the seeker, if any, caused by the environment. This subtest will be performed one time on each seeker in group A.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

27. Handling Shock.

a. Objective. Determine the operational capability of the seeker after simulated handling shock environment.

b. Standards. None applicable.

c. Method.

(1) Perform a pre-environmental SPT on the seeker to determine its operational readiness.

(2) Combine the seeker with other portions of the system in the configuration in which the system is most likely to be handled depending on the manner of deployment of the system in the field. Subject the system to simulated handling shock test.

(3) Remove the seeker and return it to laboratory ambient conditions; perform a post-environment SPT.

d. Data Required. The data required are results of the pre- and post-environmental SPT and the degree of degradation to the seeker, if any, caused by the environment. This subtest will be performed one time on each seeker in group B.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

28. Boost Shock.

a. Objective. Determine the operational capability of the seeker after simulated shock caused by ignition of the booster motor.

b. Standards. None applicable.

c. Method.

(1) Perform a pre-environmental SPT on the seeker to determine its operational readiness.

(2) Combine the seeker with simulated portions of the remainder of the missile in flight configuration. Subject the system to the shock and vibration spectrum which it receives immediately following booster ignition.

(3) Remove the seeker from the environment and return it to laboratory ambient conditions; perform a post-environment SPT to determine whether any operational degradation has resulted from the environment.

d. Data Required. The data required are results of the pre- and post-environmental SPT and the degree of degradation to the seeker, if any, resulting from the environment. This subtest will be performed one time on each seeker in group C.

e. Analytical Plan. Compare the percent of degradation to the test item to the specifications in the requirements document to determine whether the seeker meets the requirements.

SECTION III
SUPPLEMENTARY INSTRUCTIONS

29. Gyro Spin-Up Time. Gyro spin-up time (paragraph 5), gyro spin-up current (paragraph 6), and gyro spin-down time (paragraph 7) subtests may be combined and performed as one subtest to conserve operating time on the seeker.

30. <u>Maximum Look Angle</u>. Maximum look angle (paragraph 8) and recovery time (para 9) subtests may be combined and performed as one subtest.

31. <u>Signal-to-Noise Ratio</u>. Signal-to-noise ratio (paragraph 12) and cool-down time (paragraph 13) subtests may be combined as one subtest.

32. <u>Low Temperature Storage</u>. A Satisfactory Performance Test (SPT) shall consist of the subtests described in paragraphs 5, 6, 7, 11, 12, 13, 17, and 21 performed in the sequence given here. A pre-environmental SPT is performed prior to subjecting the test item to a given environment; and post-environment SPT shall be performed following the environmental test; a post-environmental SPT can serve as a pre-environmental SPT for the following environment provided that no maintenance and no adjustments are required for satisfactory operation between the two environmental tests.

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APPENDIX A
REFERENCES

1. AR 70-10, "Test and Evaluation During Development and Acquisition of Materiel".

2. AR 70-38, "Test and Evaluation of Materiel for Extreme Climatic Conditions".

3. Pivovonsky and Nagel, "Tables of Blackbody Radiation Functions," Macmillian Company, New York, 1961.

APPENDIX B
CHARTS

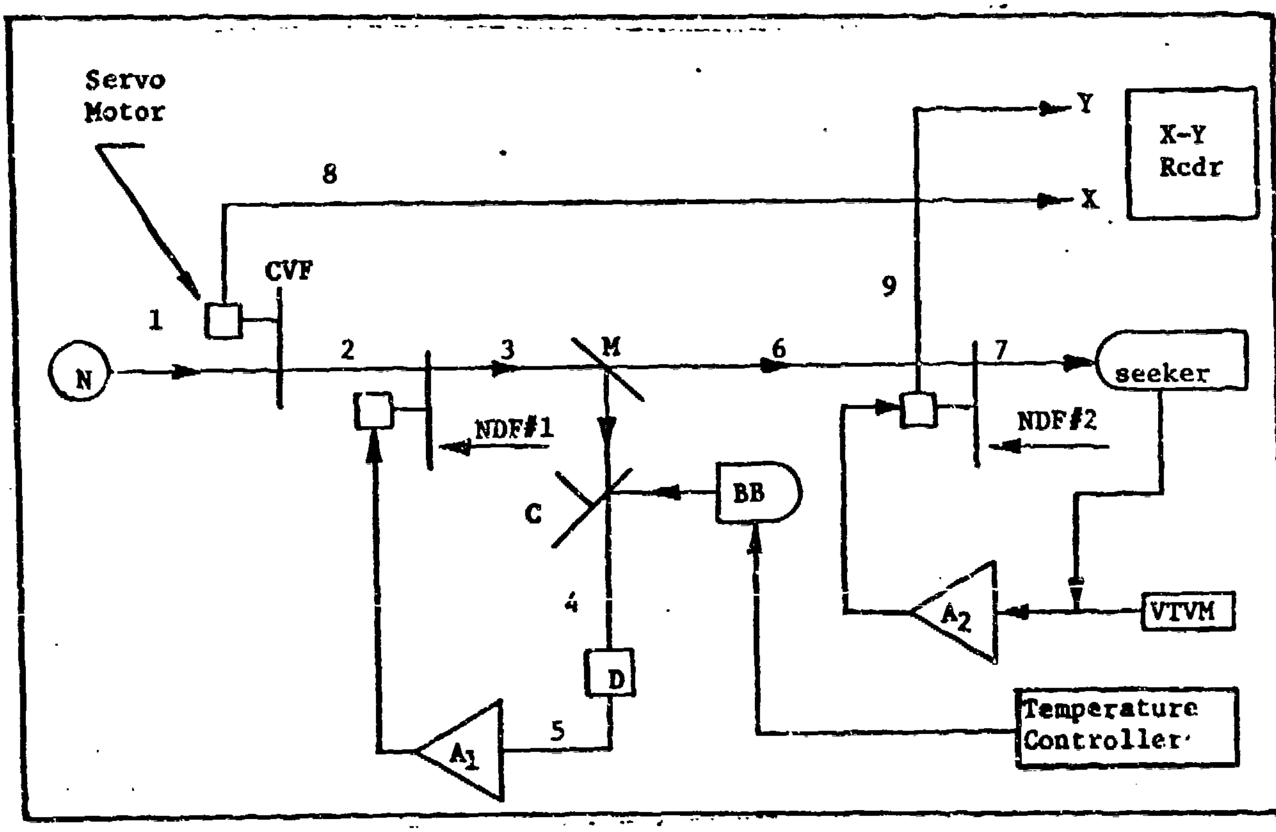


Figure 12. Infrared Signal Generator Showing Ray Trace and Partial Electrical Diagram. (Collimating and focussing optics are omitted for clarity.)

1. Infrared energy from Nernst Glower (N) is directed through a circular variable filter (CVF) used here as a monochromator.

2. Monochromatic energy has wavelength according to angular position of CVF and very narrow bandwidth; it is directed through circular variable neutral density filter (NDF#1).

3. Monochromatic energy is adjusted in amplitude according to angular position of NDF#1; it is directed to a mirror (M) which deflects the bottom half of the beam through the chopping mirror (C) and thence to the infrared detector (D) which is spectrally flat.

4. Addition of the chopping mirror (C) alternately exposes the detector (D) to energy from the source (N) and the reference blackbody (BB) which has output according to the setting of the temperature controller.

5. Detector (D) senses any difference between the energy from N and that from BB and provides a voltage through servo amplifier (A_1) to position NDF#1 which causes the energy at 3 (and 4) to be equal to that from BB.

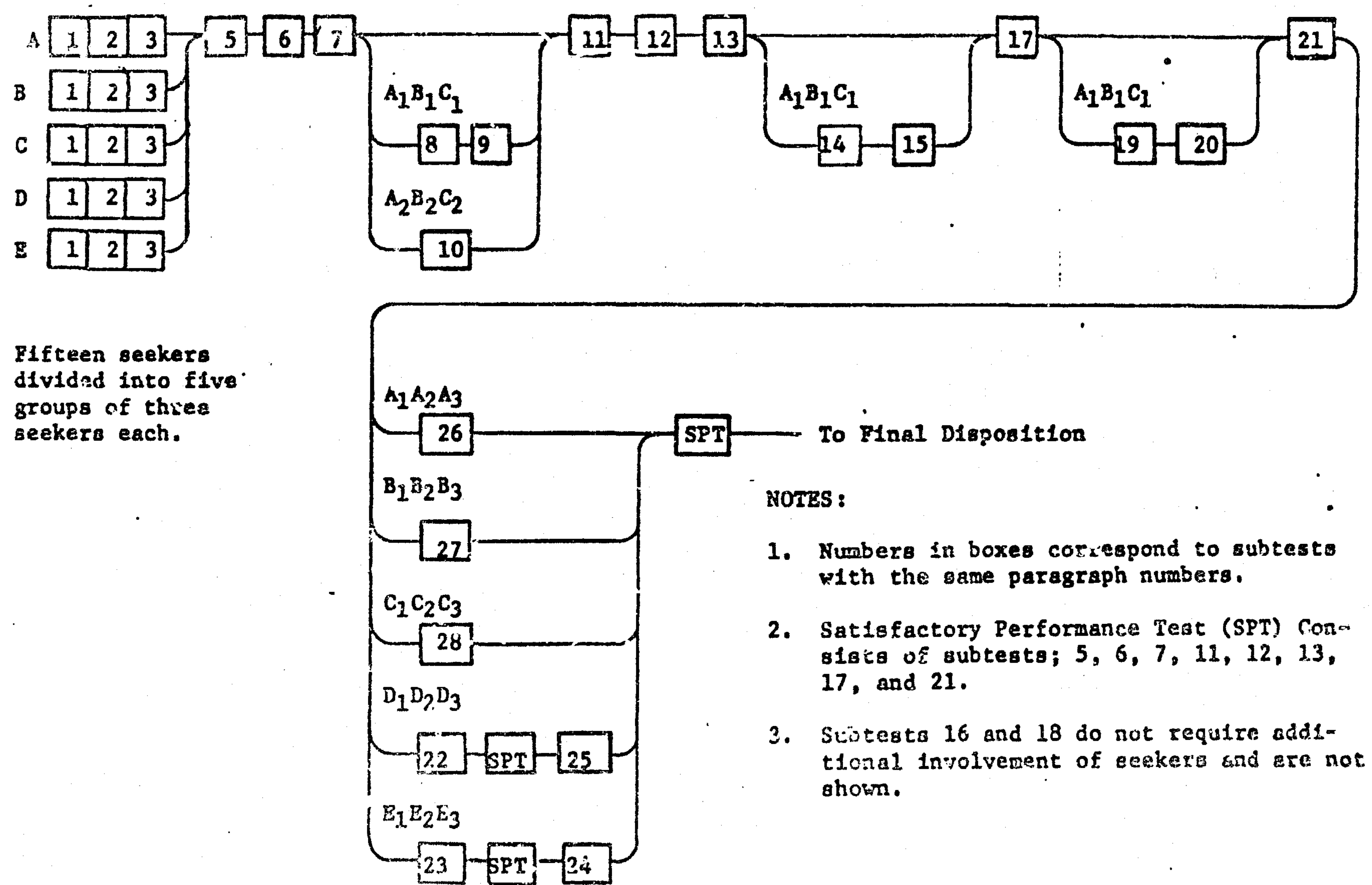
6. The top half of the energy beam from N (see 3 above) is constant in amplitude (within the flatness of D) and is directed through NDF#2.

7. Monochromatic energy of narrow bandwidth impinges on the seeker under test which outputs a voltage through servo amplifier (A_2) to position NDF#2 so that the seeker output voltage is always constant and adjustable for desired signal plus noise-to-noise ratio as indicated on VTVM.

8. A voltage proportional to wavelength (one volt per micron) is generated by CVF which is motor driven and scans the infrared spectrum once for each rotation from 0 to 10 microns. The voltage drive the X-axis of X-Y recorder linear in wavelength.

9. A voltage proportional to the angular position of NDF#2 (and therefore inversely proportional to the energy at 7 impinging on the seeker dome) is generated by NDF#2 and drives the Y-axis of the X-Y recorder proportional to the transmissivity (0 to 100 percent) of the NDF#2; the X-Y recorder, as CVF scans the infrared spectrum, draws a graph of the relative energy versus wavelength required at the seeker dome to provide a given voltage output of the seeker which can be adjusted to represent any desired signal plus noise-to-noise ratio of the seeker under test.

B-2



NOTES:

1. Numbers in boxes correspond to subtests with the same paragraph numbers.

2. Satisfactory Performance Test (SPT) Consists of subtests; 5, 6, 7, 11, 12, 13, 17, and 21.

3. Subtests 16 and 18 do not require additional involvement of seekers and are not shown.

Figure 13. Flow Chart Showing Movement of Fifteen Seekers Through the Subtests Described in Paragraphs 5 Through 28.